JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

GEOTECHNICAL ENGINEERING STREAM

Prediction of California Bearing Ratio (CBR) Value from Index Properties of Soils. Case Studies Seka Town, Jimma, Ethiopia

A Thesis Submitted to School of Graduate Studies of Jimma University in Partial Fulfilment of the Requirement of Degree of Master of Science in Civil Engineering (Geotechnical Engineering)

By:

DINKA FULEA DILBO

March, 2020

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DINKA FULEA DILBO

Main advisor: Prof. Emer T. Quezon, P.Eng

Co-advisor: Mr. Yada Tesfaye (Msc)

March, 2020

Jimma, Ethiopia

DECLARATION

I, the undersigned, declare that this thesis entitled: "**Prediction of California Bearing Ratio (CBR) Value from Index Properties of Soils. Case Studies Seka Town, Jimma, Ethiopia**" is my original work, and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for this thesis have to be duly acknowledged.

Candidate:

Mr. Dinka Fulea

_____________________ _____________

Signature Date

As Master's Research Advisors, we hereby certify that we have read and evaluated this MSc Thesis prepared under our guidance by **Dinka** entitled: "Prediction of California Bearing Ratio (CBR) Value from Index Properties of Soils. Case Studies Seka Town, Jimma, Ethiopia"

Prof. Emer T. Quezon, P.Eng	___________________	__3/13/2020_
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Mr. Yada Tesfaye, (MSc.)	___________________	_____________
Co- Advisor	Signature	Date

ABSTRACT

California Bearing Ratio (CBR) value is an important soil parameter considered as main design input in the design of flexible pavements and runways of air fields. The design of pavement thickness determined depending on the strength of subgrade soil expressed in terms of CBR (%). In the design of pavement, the suitability and stability of sub-grade materials are evaluated before construction of pavement by using CBR test. However, in a large scale road projects, conducting laboratory tests by using the CBR test is very expensive and time consuming. It also needs large soil samples which affects the cost and time of the project. In addition, Soil properties vary from region to region and season to season as it appears naturally. Therefore, developing empirical equations specific to a certain region and soil type could be considered nearly as good insight of soil behavior.

Therefore, this study was conducted to predict the CBR value from the index properties of soil to solve the difficulties in the determination of CBR value. The study was carried out using thirty samples collected from the study area. The laboratory test procedures were based on the standard procedures of American Society for Testing Materials (ASTM) and American Association of State Highway and Transportation Officials (AASHTO) method. The laboratory test result and statistical analysis were carried out using Microsoft excel and SPSS software respectively. To develop the intended correlation model the procedures of data collection, laboratory test, normality test, and correlation and regression analysis were done. The index soil properties considered for this study to establish correlations with CBR values are Percentage Passing sieve No.200, Liquid Limit (LL), Plastic Limit (PL), Plastic Index (PI), Maximum Dry Density (MDD) and Optimum Moisture Content (OMC). From the regression analysis result, the equations developed are CBR = 28.188 – 0.67OMC, and CBR = -12.124 - 0.077LL – 0.178OMC + 20.37MDD, with coefficient of determination R^2 *= 0.814 for single linear regression and* R^2 *= 0.899 for multiple linear regression respectively. Based on the result of regression analysis, fairly good correlation of CBR value is obtained with multiple parameters (LL, OMC and MDD) in multiple linear regression than with single parameters (OMC) in single linear regression. Therefore, the study concluded that during the prediction of CBR value from the index properties, the combined parameters of index properties should be used rather than single parameters. Generally, it is recommended that the result of this research could be applied for the prediction of the CBR values in different civil engineering practices.*

Keywords: *CBR Value, Index properties, Normality, Correlation, Regression.*

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LIST OF ABBREVIATIONS AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing Materials
ANOVA	Analysis of Variance
CBR	California Bearing Ratio
CT	Control Test
df	Degree of freedom
DGR	Dial Gauge Reading
E	Compaction Energy per Volume
ERA	Ethiopian Road Authority
F	Fines
G	Gravel
GI	Group Index
GS	Specific Gravity
JIT	Jimma Institute of Technology
JU	Jimma University
LI	Liquidity Index
LL	Liquid Limit
MDD	Maximum Dry Density
MPCT	Modified Proctor Compaction Test
MRE	Margin Rate Error
M.Sc.	Master of Science
MLRA	Multiple Linear Regression Analysis
MS	Sum of Square
MSE	Mean Square Error
MSR	Mean Square Regression
N	Sample Size
NMC	Natural Moisture Content
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plasticity Limit
PP200	Percentage passing sieve No.200

R	Correlation Coefficient (Pearson Correlation coefficient)
R^2	Coefficient of determination
R^2 (adj.)	Adjusted Coefficient of determination
S	Sand
SD	Standard Deviation
SE	Standard Error
SLRA	Simple Linear Regression Analysis
SPCT	Standard Proctor Compaction Test
SPSS	Statistical Package for Social Science Software
SS_R	Regression Sum of Squares
SS_E	Error Sum of Squares or Residual Sum of Squares
TP	Test Pit
SS_T	Total Sum of Squares
USCS	Unified Soil Classification System

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the discipline of Civil Engineering, Geotechnical engineering plays one of the most important roles in early stage in planning and designing of infrastructures. This is because of every civil engineering structure to be founded on the soil. Civil engineering works such as highways, buildings, dams, and other structures have a strong relationship with soil. These structures need a strong and stable layer of foundation soil to build on. Therefore, the soil must be able to carry imposed loads from any structure placed upon it without shear failure or destructive unallowable settlements [1].

Pavement design is considered to be the most important parameter in the construction of a road network, runways of air fields and bridge abutments. Generally, pavement, a relatively stable crust, is constructed over the natural soil in order to support the wheel and traffic loads as well as to provide a hard, durable and abrasion resistant surface [2].

A flexible pavement consist of a number of layers including sub-base, base course, surfacing etc. which ultimately lies on subgrade. Basically, subgrade is not the physical part of the pavement but it is considered as the functional part of the pavement. It is necessary that the subgrade soil should be properly compacted to fully utilize its strength while carrying the loads of the above layers of pavements as well as the moving loads of traffic [3]. For this purpose, it is necessary to evaluate the strength of subgrade soil on which the whole structure of the pavement rests and for this, CBR test is one of the most widely used methods. This method is mainly used to determine the stiffness modulus and shear strength of the subgrade soil and helps in designing the thickness of each layer of pavement. If the subgrade has higher CBR value, this means that it has more strength and will be able to bear more traffic load coming over it and ultimately the thickness of pavement layers will be small and vice versa [4].

California Bearing Ratio (CBR) is an important soil parameter commonly used by civil engineers particularly those involved in the design and construction of flexible pavement construction to assess the stiffness modulus and shear strength of subgrade which plays an important role in imparting structural stability to the pavement structure as it receives loads imposed upon it by road traffic [5]. The bearing strength parameter of subgrade, sub base and base course materials of road construction is determined using the California bearing ratio test. But in construction activities cost and time are of paramount importance. So carrying out these tests separately will definitely increase the cost of the construction. Therefore, a correlation between CBR value and index properties of soil will be constructive tool by saving time, efforts, and money to conduct a complete testing program.

The foremost step in the design of road pavements has always been the geotechnical evaluation of sub-grade soil material. The construction of a road starts from conception, planning and design. Without a good design of the road the functionality of the road may not be achieved. Even when the construction and supervision is adequate without the design process well done the end product in the form of a road project will not be functional. One of the main reasons why highways in the country fail is that adequate knowledge of the soil situation is not obtained before the commencement of the road work. Knowledge of the soil situation helps both at the design and construction stage of the road. The subgrade should be tested and found to be adequate and meet the standard before they will be accepted for usage in road construction work [6].

CBR (California bearing ratio) test, gives realistic results which aids the design process of new flexible pavements as well as the restoration of existing pavements all over the world. In practice, only limited number of such tests could be performed because of high unit cost and time required for such testing. As a result, in many cases, it is difficult to reveal detailed variations in the CBR values over the entire length of roads. In such cases if the estimation of the CBR could be done on the basis of some tests which are quick to perform, less time consuming and cheap, then it will be easy to get the information about the strength of subgrade over the length of roads and also will be helpful and important to construct the whole length of road in a short period of time [7].

As mentioned so far by [8], the models used should be simple enough that the physical parameters needed for computations or prediction of the model are accurately and reliably determined using inexpensive test procedures.

Therefore, in order to overcome the above-mentioned difficulties it was aimed here in this study to predict the soaked CBR value of the soil using index properties of the soil that is the percentage passing sieve no. 200, liquid and plastic limit and plasticity index and compaction characteristics such as MDD and OMC. This is because these tests are available and also are simple and can be completed within a short period of time.

1.2 Statement of the Problem

Some soil properties are time consuming and expensive to conduct in the laboratory. In geotechnical engineering there is some empirical relationships exist between one soil property and another. For this reason, for these engineering properties, it is relevant to develop empirical models that will factor in two key aspects of construction which are saving cost and time [9].

Even though various attempts have been made to predict the CBR value by different researchers from samples of their respective localities, adopting those developed prediction models for different location is not reliable due to the empirical equations developed are more reliable for the type of soil where the correlation is developed [10]. This is because of soil properties vary from region to region and season to season as it appears naturally. Therefore, developing empirical equations specific to a certain region and soil type could be considered nearly as good insight of soil behavior [11].

In addition, conducting CBR test separately increases the cost of construction as well as affects the completion time of the project, especially in large road project. This is because of conducting the conventional CBR test always been time consuming and relatively expensive, and also more quantity of samples are required for laboratory test in order to achieve better accuracy and to obtain proper idea about the soaked CBR value of subgrade materials over the entire length of the road. This is quite difficult because it is difficult to take large number of samples for a large road project. Further, if the available soil is of poor quality, suitable additives are mixed with soil and resulting strength of soil is assessed by CBR value which is cumbersome. In such case a large disadvantage associated with the CBR test is its poor reproducibility and repeatability to attain the required strength [12].

To overcome these difficulties, prediction tried to establish between and among different parameters of index properties of soil for quick assessment of CBR value. Therefore, it is very important for Geotechnical engineers to quickly predict the behaviour of foundation materials used in the construction of infrastructure such as road. So, an attempt was made in this study to predict the CBR value of soil from the index properties of soil such as the percentage passing sieve no.200, liquid limit (LL), Plastic Limit (PL), Plasticity Index (PI), Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of soil which are quick to perform in the laboratory, less time consuming and cheap, then it is easy to get the information about the strength of subgrade over the whole length of roads.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study is to predict the California Bearing Ratio (CBR) value from the index properties of soil found in Seka town.

1.3.2 Specific Objectives

The specific objectives of the study are addressed as the following one in order to achieve the general objective of the study.

- To investigate the CBR value and some index properties of the soil in the study area
- To know the relationship between California Bearing Ratio value and index properties of the soil found in the study area
- To develop a correlation model to estimate CBR value from the index properties by performing simple and multiple linear regression analysis.
- To compare the results of California bearing ratio (CBR) value of soil gained from laboratory tests with the developed correlation and to validate the developed model using the previous existing correlation data.

1.4 Research Questions

1. What will be the California Bearing Ratio (CBR) value and some index properties of soil in the study area?
2. What is the relation of California Bearing Ratio (CBR) value and index properties of soil in the study area?
3. What will be the correlation and regression analysis between California bearing ratio value and index properties of soil from the study area?
4. How much the variation between the laboratory test results and the developed correlation, and its validation using with the related study of previous existing correlation data?

1.5 Scope and Limitation of the Study

This research work is to be limited within the Seka town and focused on the prediction of CBR values from the index properties of soil found in the study area. To attempt the aim of this study, thirty representative soil samples from different location were collected to conduct this study in Seka town. The collected samples were disturbed and taken from 1m to 3m depth. The soil samples were first air dried and laboratory tests were conducted according to ASTM and AASHTO soil testing standard procedures and specifications. The study is concerned to conduct a localized research particularly on samples that are collected from Seka town. Based on the laboratory test result, prediction of CBR value from index properties such as the Percentage Passing sieve no.200, liquid limit (LL), Plastic Limit (PL), Plasticity Index (PI), Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of soil is developed using single and multiple regression statistical analysis.

Based on the trends of the scatter plot of test results the correlation was analysed using a linear regression model. The proposed correlation is carried out by applying a single linear regression model and multiple linear regression models with the aid of Microsoft excel and SPSS Software. The scope of the developed correlation, discussions and result obtained are limited to the test procedures followed, the range and quantity of sample used, apparatus used, sampling areas and methods of analysis used in the subject study.

Therefore, the findings should be considered as indicative rather than definitive for the whole study area, because the collected samples are relatively considered as a representative of the population in the study area.

1.6 Significance of the Study

This research work is to predict the California bearing ratio value from the index properties of soil such as Sieve analysis, Atterberg's limits, and Compaction characteristics of soil found in Seka town. The finding of this study will provide helpful information to various design and construction stakeholders for the purpose of different projects in the town.

Actually, Seka town is ongoing and developing town in the future. With the expansion of technology, more infrastructure such as flexible pavement will be constructed within and across this town. During this time, this finding can help as a source of information or reference for the purpose of design.

The conventional CBR testing method is expensive, time-consuming, laborious, and its repeatability is low. Especially, in the construction of long kilometres of roads, it is difficult to conduct a CBR laboratory test either as a result of huge financial involvement or scarcity of good laboratory equipment. So this finding can help to minimize the time and cost of laboratory tests, as a result, it minimizes the total duration of the project. In addition, the model may use to predict the CBR value for similar properties of soils from another site.

In addition, other researchers will use the findings as a literature review and reference for further research on the prediction of California Bearing Ratio value from the index properties of soil after it will be published.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1 Introduction

This chapter provides a review of the literature on the prediction of California bearing ratio (CBR) value from the index properties of soils. The main purpose of a literature review is to acquire more realistic and tangible information for academic and research areas that are relevant and reliable to the subject under the study of new research with related title.

2.2 Theoretical review

2.2.1 California Bearing Ratio (CBR)

CBR is defined as the ratio of the resistance to penetration of a material to the penetration resistance of a standard crushed stone base material. The California Bearing Ratio (CBR) test was first introduced by the California State Highway Department in the 1920s.The US Army Corps of Engineers then adapted the method in the 1940s for military airfields. After the Second World War, the CBR method was also used in the UK, and its use spread to European countries [13], [14].

California Bearing Ratio (CBR) test is a common and comprehensive test at present practiced in the design of pavement to survey the stiffness modulus and shear quality of subgrade material. Nowadays, the CBR test is the most widespread method of determining the bearing strength of the pavement materials and is fundamental to pavement design practice in most countries. CBR value is an indicative of the strength of the subgrade material. It is an important soil parameter considered as main design input in the design of flexible pavements [15].

The CBR value is obtained as the ratio of the unit load (in KN/m^2) required to effect a certain depth of penetration in to a compacted specimen of soil at some water content and density to the standard unit load required to obtain the same depth of penetration on a standard sample of crushed stone. This is because of the CBR may be considered as the strength of the soil relative to that of crushed stone [16].

The test may be conducted on remolded (disturbed) or undisturbed soil samples or on the soil in place at field. The samples may be tested at their natural or as molded water content (unsoaked CBR), or they may be soaked by immersing in water for the duration of four days in order to simulate highly unfavorable moisture conditions of the soil in the field.

In the laboratory test procedure, the test samples are prepared with soils of aggregate particle size of less than 19 mm. In the case of soils where particle sizes greater than 19 mm exist, the large particles are removed from the sample and replaced with an equal mass of material that falls between the 19 mm and 4.75 mm sieve size. In the field CBR test procedure, removal of larger particles that may adversely affect the test results is not possible, and, therefore, in the laboratory test these types of soil are likely to produce unreliable results because of the removal of larger particles [17].

The design of pavement thickness requires the strength of subgrade soil, subbase and base materials to be expressed in terms of CBR so that stable and economical design achieved based on the CBR value of the material. The value of CBR is an indicator of the type of subgrade soil. If the CBR value of subgrade is high, it means that the subgrade is strong, and as a result, the design of pavement thickness can be reduced. Conversely, if the subgrade soil has low CBR value it indicates that the thickness of pavement shall be increased in order to spread the traffic load over a greater area of the weak subgrade or alternatively, the subgrade soil shall be subjected to stabilization which leads to uneconomic both in cost and time [18]**.**

2.2.1.1 Application of California Bearing Ratio (CBR) Value

The strength of subgrade soil, sub-base and base-course material should be expressed in terms of California Bearing Ratio to use it as design input in the design of pavement thickness in road construction to achieve a stable and economic design. The required pavement thickness is determined from this CBR percentage by a method which is essentially empirical. The bearing ratio value is entered into an appropriate wheel loading curve to give the required thickness of pavement and its component layers depending on the accumulated traffic weight.

The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. A number of pavement design charts are published in which one enters a chart with the CBR (Structural Number) together with design traffic class and reads directly the thickness of sub base, base-course, and/or flexible pavement thickness based on expected wheel loads.

The main application of California Bearing Ratio (CBR) is to evaluate the suitability of shear strength of natural subgrade soil as a construction material. The determination of the thickness of the pavement layer is governed by the strength of sub grade. If the CBR value of subgrade is high, it means that the subgrade is strong and as a result, the design of pavement thickness can be reduced in conjunction with the stronger subgrade. Conversely, if the subgrade soil has low CBR value it indicates that the thickness of pavement shall be increased in order to spread the traffic load over a greater area of the weak subgrade or alternatively, the subgrade soil shall be subjected to treatment or stabilization.

The other application of CBR value in pavement design is the road sections must be defined and assigned in accordance with subgrade strength classes depending on the range of CBR value [19].

Table 2.1: ERA Classification of Sub grade Strength Class

Subgrade Strength Class	Range of CBR Value (%)
S1	2
S2	3-4
S3	5-7
S4	8-14
S5	15-29
S6	30 and above

Therefore, the information on the stiffness modulus and shear strength of subgrade soil should be required before any pavement design is carried out. These parameters are necessary to determine the thickness of the overlying pavement in order to achieve optimum and economic design [20].

2.2.2 Index Properties of Soil

In nature, soil occurs in a large variety. Engineers are continually searching for simplified tests that will increase of soils by employing a rapid soil test. These simplified tests, which engineering properties of soils are called index properties. Index properties of soil are properties which are used to characterize soils and facilitate identification and classification of soils for engineering purposes. Index properties of cohesive soils are used to characterize the physical and mechanical behavior of soils by making use of basic properties such as moisture content, specific gravity, particle size distribution, Atterberg limit, and moisture-density relationships. The wide applications of index properties in geotechnical engineering practice are to identify and classify cohesive soils and provide correlations with engineering soil properties [21].

2.3 Review of Empirical Correlations of CBR value

In this section some of the available literature regarding the empirical correlation between CBR value and different index properties of soil have been developed by different researchers was reviewed in order to accomplish the proposed objectives of this research. In Geotechnical engineering various researchers have been contributed immensely to develop the prediction equations for CBR using different soil properties. Some of this literature was reviewed as the following one.

Z. U. Rehman *et al.* [22] were developed Correlations separately for fine grained soils and coarse grain soils. They were used 84 sample. Among 84 tested samples, 59 samples test results were utilized for the development of correlations and 25 were utilized to check the validity of developed correlation. Based on their soil test results, they were established different relationships. According to [22], it was observed that with an increase in fines the CBR value tends to decrease i.e. Strength of this relationship is very poor. The relationship was also established between CBR soaked value, optimum moisture content and maximum dry density. It was observed there is a linear relationship between CBR soaked value and optimum moisture content for both fine grained and coarse grained soil. With an increase in optimum moisture content of soil CBR soaked tends to decrease. Similarly, a linear relationship was observed between CBR soaked value and maximum dry density, CBR soaked tends to increase with the increase in maximum dry density of soil. Liquid limit and plasticity index are two very important index properties of fine grained soils. In their study from the regression analysis it was observed that with an increase in liquid limit and plasticity index, CBR soaked Value tends to decrease for fine grained soil indicating very less scatter and good correlations. For fine grained soils they were proposed the following developed model for the prediction of soaked CBR Value.

$$CBRsoaked = -0.10LL - 0.425PI + 15.73, \text{ with } R^2 = 0.9 \quad (2.1)$$

P.G. Rakaraddi and Vijay Gomarsi [23] had proposed a correlation between CBR value and index properties such as Gravel (G), Fines (F), Sand(S), LL, PL and compaction characteristics such as MDD and OMC using Multiple Linear Regression Analysis. The correlations proposed are written as the following equations.

a) By correlating soaked CBR with optimum moisture content and maximum dry density Mathematical equation is generated as given below.

$$CBR = -0.26052OMC+5.717093MDD \text{ with } R^2=0.940 \quad (2.2)$$

b) By correlating soaked CBR with Liquid limit, plastic limit, fines, and specific gravity Mathematical equation is generated as given below.

$$CBR = -0.275LL+0.118PL+0.033F+5.106G \text{ with } R^2=0.961 \quad (2.3)$$

c) By correlating the soaked CBR value with percentage fineness, optimum moisture content, plasticity index, and specific gravity, the mathematical equation is generated as given below.

$$CBR = 0.030F - 0.426OMC - 0.117PI+5.471G \text{ with } R^2=0.951 \quad (2.4)$$

d) By correlating soaked CBR with optimum moisture content and specific gravity the mathematical equation is generated as given below.

$$CBR = -0.557OMC+5.943G \text{ with } R^2=0.931 \quad (2.5)$$

Srinivasa R.H *et al*. [24] were investigated on Black Cotton soils from different parts of Karnataka state, India to develop regression equations for the prediction of CBR values. Black cotton soil in this area is generally grayish brown to black in color and occur from 0.5m to 10m deep and have high compressibility. The soil selected for testing in the selected area is generally classified as "CH"–Inorganic clay with high compressibility. After conducting different laboratory tests on 26 black cotton soil samples, based on the results an attempts were made to correlate the CBR values with the Index properties of the soil like Liquid limit, Plasticity Index, Activity of the soil and Compaction characteristics of the soils. Using statistical package for social science, SPSS software program linear regression equations like multiple linear regression equations were tried to develop correlation. After several trials were made through regression analysis they were provided the following equation in their study. For their developed equation they conclude that the correlation between CBR with MDD and OMC is better, if other properties viz., Activity and Plasticity Index is used.

$$CBR = 6.536 - 0.064Ip - 0.018A - 0.019OMC - 0.391MDD \text{ with } R^2 = 0.958 \quad (2.6)$$

Faisal I. *et al*. [25] Were attempted to correlate CBR value of soil with its index properties like grain size analysis, Atterberg's limits, and compaction characteristics such as MDD (Maximum Dry Density) and OMC (Optimum Moisture Content). To develop suitable correlations between CBR value and the index properties of Jamshoro soil which includes

LL, PL (Plastic Limit), PI (Plasticity Index), OMC, MDD, percentage passing of soil fines (%F) by the help of SLRA and MLRA which is the main theme of their research work. Index properties and CBR values of these samples have been determined through laboratory testing according to AASHTO and ASTM specification procedures. In their paper they mentioned important correlations which have been developed through SLRA and MLRA on CBR and index properties of various soil samples in Jamshoro. From the developed MLRA models for Soaked CBR based on the values of coefficient of determination (R^2) and adjusted coefficient of determination (Adj. R^2), it has been noted that the following model provided a better correlation with LL, PI and % Finer with value of R^2 = 0.984 and Adjusted R^2 = 0.935

$$CBRS = 11.2525(LL) - 26.4144(PI) - 0.3024(\%F) + 153.717 \text{ with } R^2 = 0.984, \text{ Adj. } R^2 = 0.935 \quad (2.7)$$

B. Yildrim, O. Gunaydin. [26] proposed the following correlation for CBR soaked value with index properties of fine-grained soils.

$$CBR = 0.62OMC + 58.9MDD + 0.11LL + 0.53PL - 126.18 \text{ with } R^2 = 0.63 \quad (2.8)$$

Dino Abdela [10] was studied on Correlation of California Bearing Ratio (CBR) with Index Properties of Soils. His study is concerned to conduct a localized research particularly on subgrade material. For achieving the objective of the study, different laboratory tests were carried out on thirty samples that collected along the stated road. Based on the results obtained , the correlation of CBR with index properties of the soil (LL, PL, PI, Percentage of fine content(F), Percentage of sand content(S), Percentage of gravel content(G), MDD and OMC) is developed using statistical regression analysis.

From the correlation analysis developed, he was provided the following two models using single linear regression and multiple linear regression respectively with the help of Statistical data analysis commercially available software namely MINITAB, SPSS and Microsoft Excel.

$$CBR = 17.227 – 0.867PI + 0.013PI^2, \text{ with } R^2 = 0.682 \quad (2.9)$$

$$CBR = 3.591 – 0.013F + 3.707MDD – 0.098PI \text{ with } R^2 = 0.731 \quad (2.10)$$

From his study he observed and concluded that the effect of fine, plasticity index, liquid limit, plastic limit and optimum moisture content have negative effect on CBR value. That means if fine content , liquid limit, plastic limit , plasticity index, optimum moisture content tends to increase, the CBR value tends to decrease. Therefore, from this it can be concluded that the presence of much fine particles, high water content and plasticity affect soil strength. And also he observed that increasing maximum dry density and percentage of gravel content have positive effect on CBR value. For instance, if MDD and G increases CBR tends to increase. This shows coarser materials and high density soils gives better strength. From the result he obtained from his study, he also concluded that the combination of soil index properties (grain size analysis, Atterberg's limit, and compaction parameters) correlates better than individual soil properties. The result shows that the correlation is sufficiently accurate in determining the CBR and hence can be used for preliminary characterization purpose within the soil property ranges used in the study.

Yared Leliso [18] was studied on Correlation of CBR Value with Soil Index Properties for Addis Ababa Subgrade Soils, using forty two disturbed samples that are collected from different parts of Addis Ababa and tried to develop the correlation of CBR as a function of grain size parameter, Atterberg's limits and compaction parameters by considering the effect of an individual soil properties and effect of a combination of soil properties on the CBR value. The study showed a combination of soil index properties correlates better with strength characteristic of CBR than individual soil properties. He suggested that for preliminary design purpose the correlation might be used, if the predicted CBR value is within the range of 2.2% to 10%. Otherwise, a detailed laboratory test should be carried out to obtain the actual CBR value. The developed correlation provided by Yared Leliso is presented below.

$$CBR = -21.734 - 0.003LL - 0.137PI + 20.244MDD, \text{ with } R^2 = 0.629 \quad (2.11)$$

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Description of the Study area

The study was conducted in western Oromiya region, Jimma Zone at Seka town. Seka town is found in Jimma zone, Oromiya region which is located in south-western Ethiopia and located 347km from Addis Ababa. It is the administrative center of Seka Chekorsa woreda. Its geographical coordinates are 07° 35'N latitude and 36° 33'E longitude with an estimated area of 1,607.66 square kilometers. The altitude of this town ranges from 1580 to 2560 meters above sea level. It lies in the climatic zone locally known as Weyna Daga, which is considered ideal for agriculture as well as human settlement. The mean annual rainfall of the area is between 1800 mm to 2300 mm with maximum rainfall between months of June and September. The annual mean temperature of the area is between 15 ^{0}C and 25^{0}C [27]. The Global coordinates (Latitude and Longitude), map and soil sample location of the study area are shown in table 3.1, figure 3.1 and 3.2 below respectively.

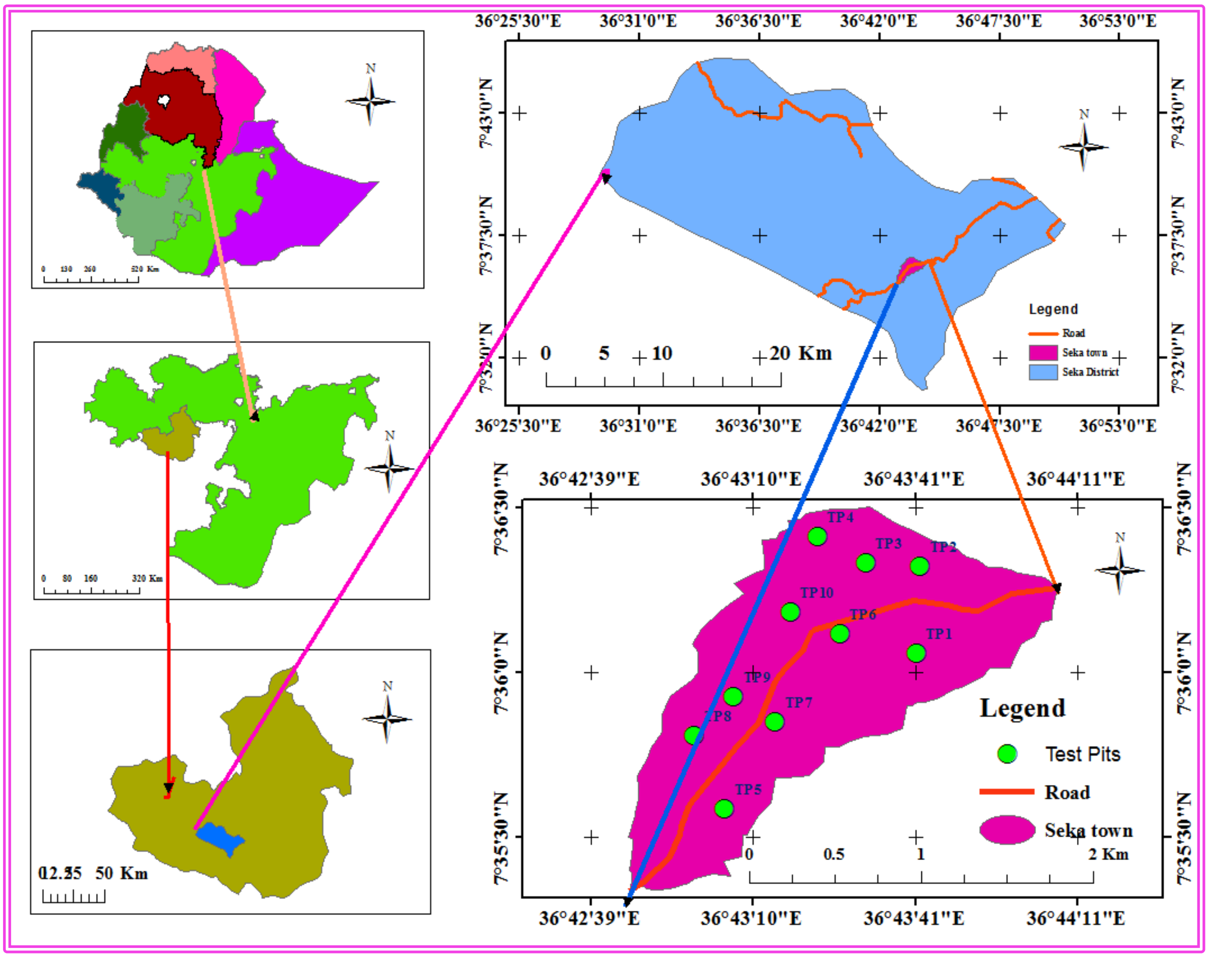


Figure 3.1: Map of the study area

Table 3.1: Global Coordinates for Identification of Soil Sample Test Pit Location

Test Pits	Name of Location (Site)	Global Coordinates	
		Northing (Latitude)	Easting (Longitude)
TP-1	Seka Agricultural Office	7.604490	36.728574
TP-2	Seka Town Bus Station	7.605498	36.728223
TP-3	Police Office	7.605661	36.725349
TP-4	Seka Administration Office	7.607026	36.722847
TP-5	Seka Town Municipality Office	7.596312	36.717457
TP-6	Seka High School	7.600031	36.721817
TP-7	New Generation KG School	7.597461	36.720632
TP-8	Seka Hospital	7.596747	36.716393
TP-9	Seka Preparatory School	7.598789	36.718470
TP-10	Lideta Orthodox Church	7.603117	36.721428

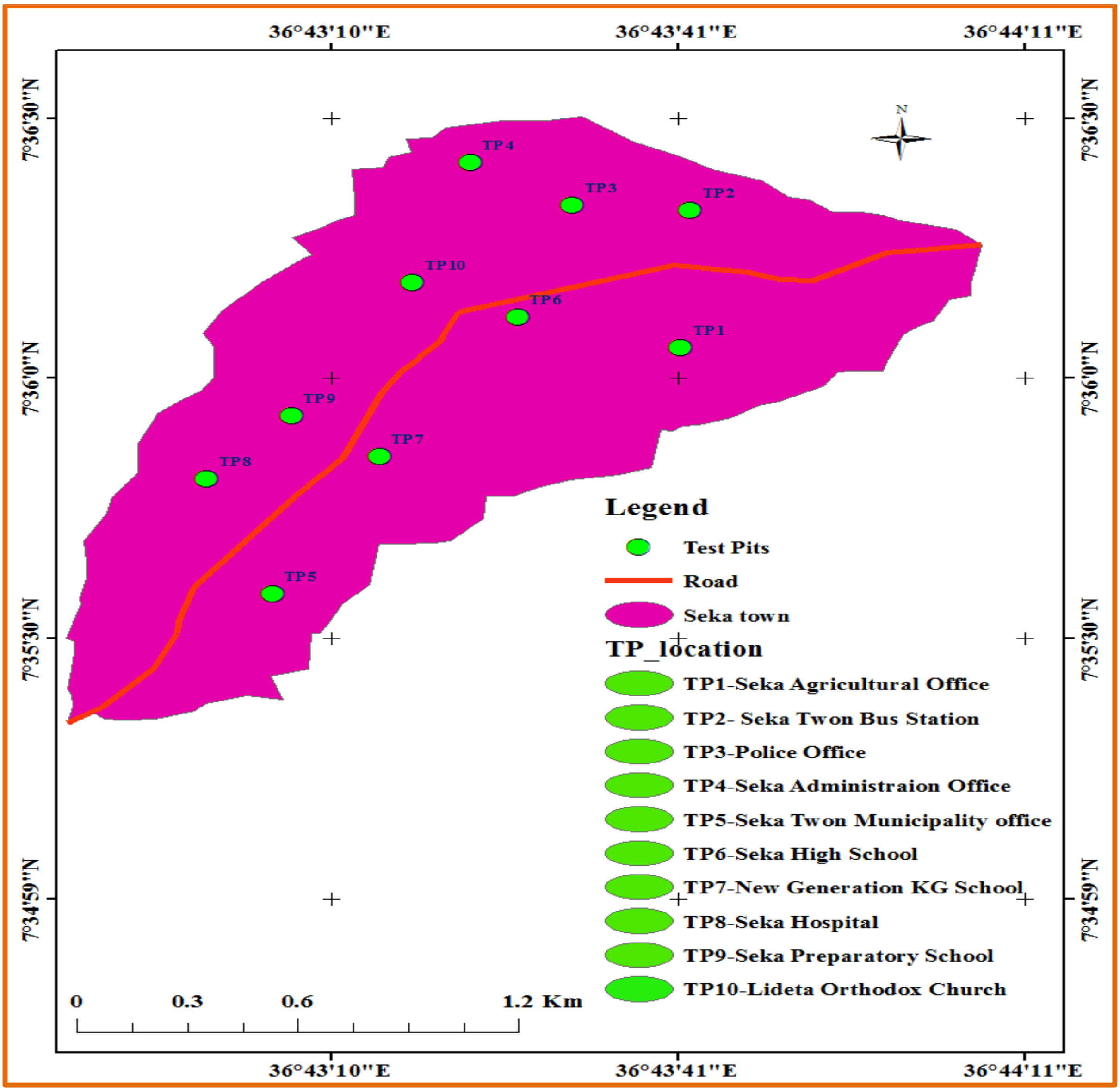


Figure 3.2: Identification of Soil Sample Location of all Test Pits from the Study area

3.2 Data Collection

Before selecting sampling areas, visual site investigation and information from Seka town Municipality and Seka town administration were collected to consider soil types and to take sample evenly in the whole town. After observation of different locations in the study area, ten sampling locations were selected within different location of Seka town.

3.2.1 Sampling

Sampling is related with the selection of a subset of individuals from within a population to estimate the characteristics of whole population [28].

3.2.2 Sampling Techniques

The method for the selection of an individuals on which information are to be made is called sampling techniques [28].

3.2.2.1 Random Sampling

In this method of sampling, each unit included in the sample will have certain pre assigned chance of inclusion in the sample. This sampling provides the better estimate of parameters in the studies in comparison to the others methods of sampling. Randomization within an experimental design is a way of ensuring control over confounding variables and as such it allows the researcher to have greater confidence in identifying real associations between an independent variable (predictor) and a dependent variable (outcome measure) [28]. In random sampling every individual in the population must have an equal probability of being selected and the selected sample can have high probability to represent the population [29]. Therefore, this method of sampling was applied in this study to have a representative sample.

3.2.3 Sample Size

Ten test pits were excavated using local labor and samples were collected from each test pits at different depth in different parts of Seka town. Up to three soil samples were taken from one test pit, and additional nine samples were taken. In total 39 disturbed samples collected for further laboratory test. The collected samples were further analyzed in the laboratory conducting laboratory tests such as Grain size analysis, atterberg's limits test, compaction test and California Bearing Ratio test to categorize the soil type and determine the regression and correlation analysis using the analyzed result. Among 39 tested samples, 30 samples test results were utilized for the development of correlations and 9 samples were utilized as control test to check the validity of the developed correlation.

3.2.4 Sampling procedures

Test pits were excavated using hand tools carefully and representative samples were extracted. The samples properly handled and preserved using a plastic bag to prevent contamination by foreign material and to ensure that the in-situ soil conditions are preserved. The preserving and transporting of the samples was performed according to ASTM D-4220-95 (standard Practice for Preserving and Transporting of Soil samples).

3.3 Research Design

Research design shows the general flow chart of the study. This is shown as figure below.

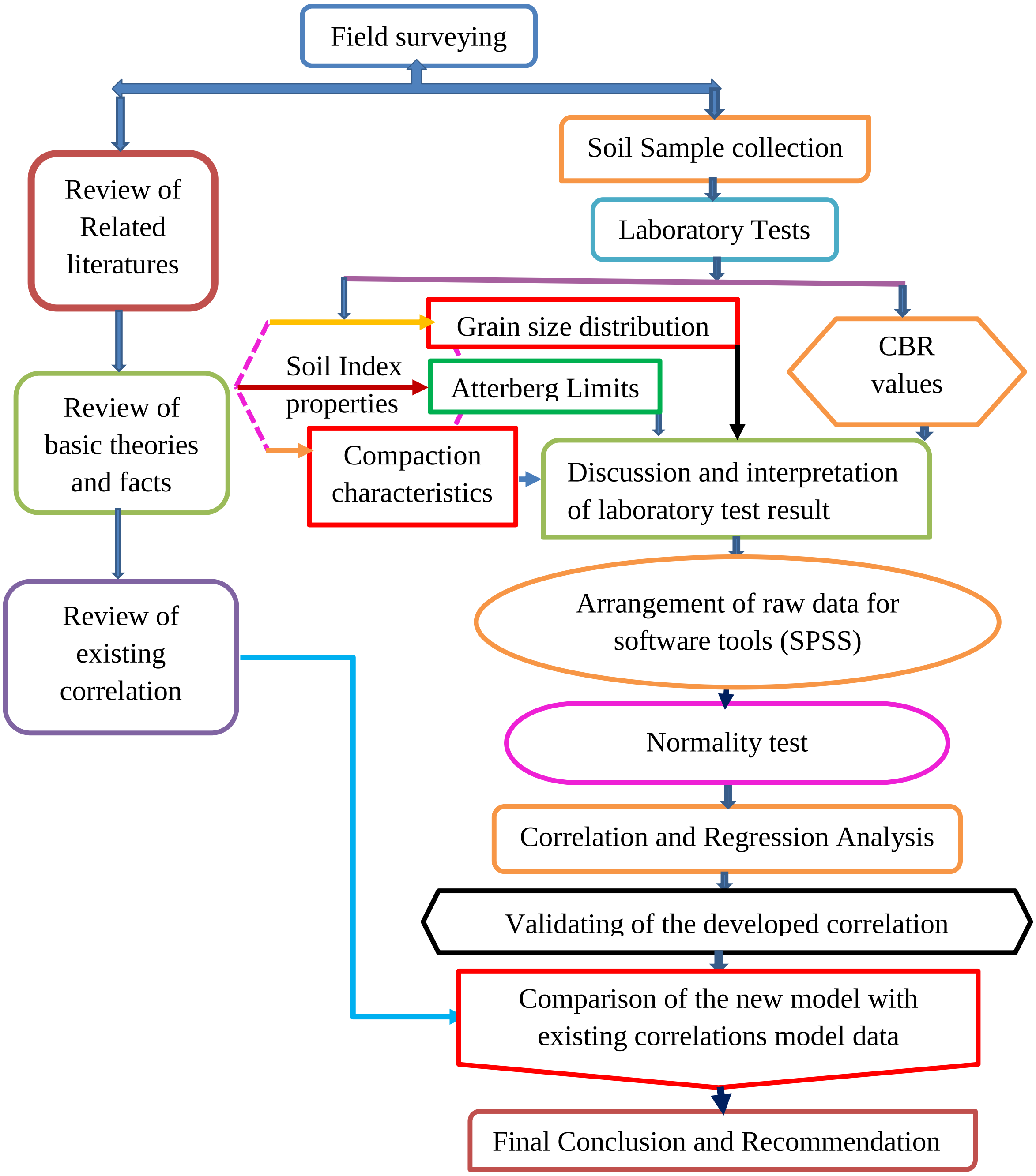


Figure 3.3: Overall flow Chart of the Study

3.4 Study variables

3.4.1 Dependent variable

The dependent variable is the response variable or output determined from the effects of the independent variable defining as a function of different index soil properties (independent variable) in the form of equation by the method of regression analysis (both simple linear regression and Multiple linear regression analysis). For the purpose of this study dependent variable is considered as the California bearing ratio (CBR) value of soil which was predicted based on the independent variable.

3.4.2 Independent variables

Independent variables are the variables that factor which are measured by the experimenter to determine its relationship to observed phenomena. For this research, the independent variables are the soil index properties such as Percent passing sieve no.200, atterberg limits parameters (LL, PL and PI) and compaction characteristics (MDD and OMC).

3.5 Laboratory Tests

The engineering properties of soils are classified and identified based on index properties and other tests. Several laboratory tests had been undertaken to produce model equations using the obtained result. Specifically, for this research laboratory tests such as natural moisture content, Specific gravity, Grain size analysis, Atterberg's limits, compaction test and California Bearing Ratio (CBR) test were conducted.The entire laboratory tests were conducted in Jimma Institute of Technology Department of Civil Engineering Geotechnical Engineering Laboratory using the following standard testing procedures, and the detail laboratory tests described as table 3.2 below.

Table 3.2: Summary of laboratory standard testing procedures

Test Description	Standard Methods of Testing Procedure
Natural Moisture Content	ASTM D 2216-98a
Specific Gravity	ASTM D 854-98
Grain Size Distribution Analysis (Wet Sieve Analysis)	ASTM D 1140-97
Atterberg Limits Test	ASTM D 4318-98
Compaction Test	AASHTO T-180
California Bearing Ratio Test	AASHTO T-193

3.5.1 Natural Moisture Content

Moisture content is defined as the ratio expressed as a percentage of the mass of water to mass of soil solids. The purpose of moisture content test is to determine the amount of water present in a quantity of soil in terms of its dry weight.

The water content of a soil is used in expressing the phase relationships of air, water, and solids in a given volume of soil. In (cohesive) soils, the consistency of a given soil type depends on its water content [30]. The other importance of moisture content is to provide general relation with strength, settlement, workability and other properties, because change in moisture content is the most important soil index property that affects the property of soils since their behavior largely changes with water concentration variation.

3.5.2 Specific Gravity

Specific gravity of soil is the ratio of weight of a given volume of soil particles in air at a stated temperature to the weight of an equal volume of distilled water at a stated temperature. The specific gravity of a soil is used to relate a weight of soil to its volume. It also used to calculate phase relationships of soils [31].

3.5.3 Grain Size Distribution

To understand the nature of the soil, the distribution of the grain size present in the given soil mass must be known. Therefore, the grain size analysis involves determining the percentage by mass of particles within the different size ranges. The purpose of grain size (sieve analysis) is to determine the percentage of various grain sizes. The grain size distribution is used to determine the textural classification of soils (i.e., gravel, sand, silt clay, etc.) The distribution of particle sizes larger than 75 µm (retained on the no. 200 sieve) is determined by dry or wet sieving, while the distribution of particle sizes smaller than 75 µm is determined by a sedimentation process, using a hydrometer to secure the necessary data. Then the percent passing on each sieve is used for further identifying the distribution and gradation of different grain sizes.

3.5.4 Atterberg Limits

Atterberg Limits are integral parts of several engineering classification systems to characterize fine-grained soil. It describes the consistency and plasticity of fine-grained soils with varying degrees of moisture content. Albert Atterberg, a Swedish Scientist in 1911, gave an idea of the consistency limit of cohesive soils and proposed a number of tests for defining their properties. For the portion of the soil passing the 0.425mm (No. 40) sieve, the moisture content is varied to identify the three stages of soil behavior in terms of consistency. These stages are known as the liquid limit (LL), plastic limit (PL), and shrinkage limit (SL) of soils. Their test is performed only on that portion of a soil which passes the 0.425mm (No.40) Sieve [32].

I) The liquid limit (LL) is defined as the water content at which 25 blows of the liquid limit machine (Casagrande cup) closes a standard groove cut in the soil part for a distance of 12.7 mm. It also may be defined as the minimum water content at which the soil will start to flow under the application of a standard shearing force (dynamic loading).

II) The plastic limit (PL) is as the water content at which a thread of soil, when rolled down to a diameter of 3 mm, will begins to crumble or fracture.

III) The shrinkage limit (SL) is defined as that water content below which no further soil volume change occurs with further drying.

The Atterberg limits provide general indices of moisture content relative to the consistency and behavior of soils. The LL defines a liquid/semi-solid change, while the PL is a solid boundary. The numerical difference is termed as the plasticity index (PI = LL-PL). It is the range of water content over which the soil remains deformable or plastic.

3.5.5 Soil Classification

Soil classification is the distribution of soils into different groups such that the soils in a particular group have similar property. It is the type of labelling of soils with similar size. Soils exhibiting similar behavior can be grouped to form a particular group under different standardized classification systems. A classification scheme provides a method of identifying soils in a particular group that would likely exhibit similar characteristics. As there is a wide variety of soils covering the earth, it is desirable to classify the soils into broad groups of similar property [33].

There are various soil classification systems existing in the world, presently, two of classification systems are frequently used by geotechnical and soil engineers. They are the American Association of State Highway and Transportation Officials (AASHTO) classification system and the Unified Soil Classification System (USCS) which are used to specify a certain soil type that is best suitable for a specific application. Both systems take into account the particle-size distribution and Atterberg limits. These classification systems divide the soil into two groups: cohesive or fine-grained soils and cohesion-less or coarse-grained soils [34].

3.5.5.1 Unified Soil Classification System (USCS)

This type of classification system is the most common for use in all types of engineering problems including soils. This type of system classifies soils into two broad categories:

Coarse-grained soils that are gravelly and sandy in nature with more than 50% retained through the No.200 sieve. The group symbols start with a prefix of G or S. G stands for gravel or gravelly soil, and S for sand or sandy soil.

Fine-grained soils are with less than 50% retained through the No.200 sieve. The group symbols start with prefixes of M, which stands for inorganic silt, C for inorganic clay, or O for organic silts and clays. The symbol Pt is used for peat, muck, and other highly organic soils [35].

3.5.5.1.1 Plasticity Chart for Unified Soil Classification System (USCS)

The plasticity chart is a plot of the plasticity index versus the liquid limit of a soil and it is used for classifying fine-grained soils according to their plasticity. The A line (PI= 0.73(LL-20)) is an empirically chosen line that splits the chart between clays above the A line and silts below the A line. The vertical line, corresponding to a liquid limit equal to 50%, separates high-plasticity fine-grained soils (LL>50) from low-plasticity fine-grained soils (LL<50).To classify a soil, the plasticity index and liquid limit of that soil are plotted on the chart having the A line; the region in which the point falls indicates what type of fine-grained soil it is or what kind of fines are encountered in a coarse-grained soil. The plasticity chart is the basis for the classification of fine-grained soils and of the fines fraction of coarse-grained soils [36]. This plasticity chart for Unified Soil Classification System (USCS) is shown as the following figure.

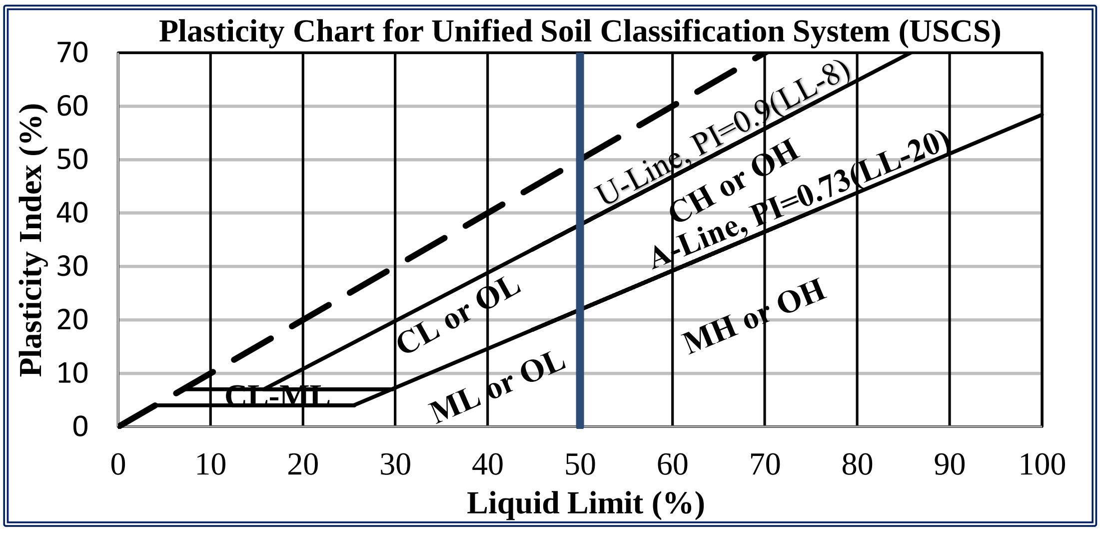


Figure 3.4: Plasticity Chart for Unified Soil Classification System (USCS), (ASTM D2487)

3.5.5.2 AASHTO Classification System

In 1928, the Bureau of Public Roads introduced a classification system with seven soil groups, designated A-1 through A-7, to be used for assessing the suitability of road subgrade materials. This system is based on the proportion of grain diameters falling between 2.0, 0.425, and 0.075 mm (sieve No. 10, 40, and 200) as well as the soil's plasticity. It is a quick, rational method for categorizing both undisturbed natural soil and fill in terms of its performance as a subgrade material. The system has been found to be applicable in areas with vastly different soil types and origins. The seven classifications is shown in Table 3.3 below [37].

Table 3.3: AASHTO classification of soils and soil-aggregate mixtures (AASHTO M 145-91)

Classification Of Soils and Soil-Aggregate Mixtures											
General Classification	Granular Materials (35% or less passing 75µm) [No.200]							Silt-Clay Materials (More than 35% passing 75µm) [No.200]			
Group Classification	**A-1**		**A-3***	**A-2**				**A-4**	**A-5**	**A-6**	**A-7**
	A-1-a	**A-1-b**		**A-2-4**	**A-2-5**	**A-2-6**	**A-2-7**				**A-7-5 A-7-6**
Sieve Analysis											
Percent passing											
2mm (N0.10)	50 max.	…..	…..	…..	…..		…..	…..	…..	…..	…..
425µm (No.40)	30 max.	50 max.	51 min.	…..	…..	…..	…..	…..	……	……	….
75µm (No.200)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	35 mi.	35 min.	35 min.	35 min.
Characteristics of fraction passing 425µm (No.40)											
Liquid Limit	……		…..	40 max.	41min.	40 max.	41 min.	40 max.	41 min.	40 max.	40 min.
Plastic Index	6 max.		N.P.	10 max.	10 max.	10 min.	10 min.	10 min.	11 max.	11 min.	11 min.**
Usual Types of significant Constituent Materials	Stone Fragments Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good							Fair to Poor			

*The placing of A-3 before A-2 is necessary in the “left to right elimination process” and does not indicate the superiority of A-3 over A-2.

**The plasticity index of A-7-5 is equal to or less than the liquid limit minus 30. The plasticity index of the A-7-6 subgroup is greater than the liquid limit minus 30.

There are two broad types under which the AASHTO groups and subgroups are divided. These are "granular" (A-1, A-3, and A-2) and "silt-clay" (A-4 through A-7) materials. The transitional group, A-2, includes soils which exhibit the characteristics of both granular and silt-clay soils, making subdivision of the group necessary for adequate identification of material properties. The engineering considerations for granular and silt-clay soils are significantly different. The following discussion highlights the major differences between these two types.

1. Granular: Granular materials include mixtures of rock fragments ranging from fine to coarse grained. Granular materials may include a non-plastic to slightly plastic soil binder, but are limited to 35 percent or less of the soil passing the 0.075mm (No. 200) sieve (Note that Mn/DOT's Specification limits granular backfill to no more than 20 percent passing the 0.075mm(No.200) sieve). Granular materials generally provide the most desirable subgrade.

It is possible, however, that some granular materials near the silt-clay boundary may have characteristics unsuitable for roadways in the presence of water. This is because capillarity (or a chemical affinity for water) may induce a volume change or softening of the material. In addition, frost heave becomes a concern in materials with high silt contents. Therefore, the elevation of the ground water table should be carefully considered when the subgrade is composed of these transitional soils

2. Silt-clay: Silt-clay materials are soils having more than 35 percent passing the 0.075mm (No. 200) sieve. The behavior of these soils is dominated by the fines in the soil mass. Silt-clay materials (A-4 through A-7) can provide suitable road subgrades when their shortcomings are accounted for by proper design or construction practices. Subgrades classified as A-6 or A-7 usually dictate a thickened pavement section and strictly maintained grading tolerances. A-7 materials are generally considered the poorest performers with regard to roadway construction.

Determining the AASHTO classification of a soil is a two-step process. First, the soil is categorized into one of the seven major “A” groups using the gradation limits set in Table above. Generally, the lower-numbered soils to the left of the chart are more preferable subgrade materials than those on the right. However, this is not always true: A-3 materials usually outperform A-2 materials. A subdivision of some of the major groups is necessary to account for varying characteristics, e.g. A-2-6 and A-2-7.

3.5.5.2.1 Plasticity Chart of AASHTO Classification System

By plasticity chart of AASHTO Classification, the relationship between liquid limit and plasticity index for silt-clay groups (from AASHTO M 145-91), and where the subgroups division of the material falls can be checked graphically using figure below.

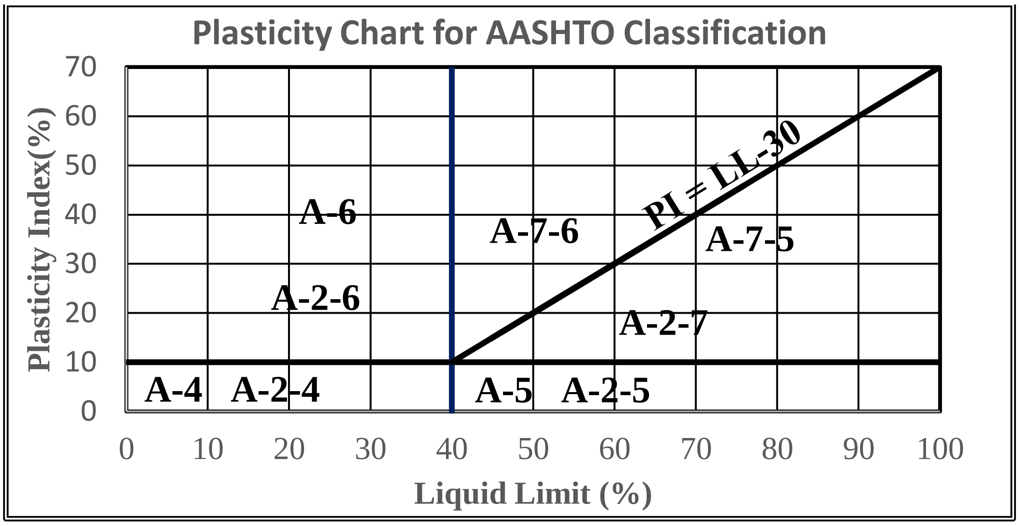


Figure 3.5: Relationship between liquid limit and plasticity index for silt-clay groups (AASHTO M 145-91).

3.5.5.2.2 AASHTO Group Index Value

Group index value (GI) is an indicator of suitability of subgrade soil for highway construction. Different soil class under AASHTO classification are generally rated for subgrade suitability from excellent to good for coarse graded material and good to poor for fine graded soil [33]. This parameter used as a general guide to the load bearing capacity of a soil. The group index is a function of the liquid limit, the plasticity index and the amount of material passing 0.075mm sieve size.

$$GI = (F-35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(PI - 10) \quad (3.0)$$

Where: F- Percentage passing sieve No. 200 (size 0.075mm), whole number

LL- Liquid Limit, expressed as a whole number

PI- Plasticity Index, expressed as a whole number

While calculating the GI from the above equation, if the computed value is negative, the group index is reported as zero. In addition, the GI value is rounded off to the nearest whole number. The higher the value of the group index for a given group classification the poorer the performance as a subgrade material. A group index of zero indicates a good subgrade, whereas a group index of 20 or greater shows a very poor subgrade. In other way, increasing the value of the group index within each basic soil group reflect the combined effect of increase in liquid limit and plasticity index and also decreasing percentage of coarser material resulting in decrease in the load carrying capacity of subgrade. In this regard, the idea of Group Index is similar to CBR in a way that both are an indicator of the suitability of subgrade soil.

The main importance of group index is to identify the better performance of different soil group, even different soils fall under the same soil group but may have different value of GI as a highway sub grade material. Generally, the soil that has a lower value of group index is likely to perform better as a highway sub grade material.

3.5.6 Moisture-Density Relationship

According to Arora, k.R. [33] Compaction of soil means to densify the soil by using the mechanical technique in order to improve the engineering properties of soil. Compaction generally increases the shear strength of the soil, and hence the stability and bearing capacity. It is also useful in reducing the compressibility and permeability of the soil. It is a general practice and common methods in geotechnical engineering to construct; road, dams, landfills, airfields, foundations, hydraulic barriers, and ground improvements.

3.5.6.1 Factors Affecting Compaction

Besides moisture content, soil type and compaction effort (energy per unit volume) are factors that affect compaction [38]. The importance of these two factors is described below.

3.5.6.2 Effect of Soil Type

The soil type is described depending on its grain-size, shape of the soil grains, specific gravity of soil solids, and amount and type of clay minerals present. These factors has a great influence on the maximum dry unit weight and optimum moisture content. Coarse-grained soils tend to reach optimum compaction at water contents lower than fine-grained soils, and tend to reach maximum dry densities that are higher than those of fine-grained soils because of fine-grained soils have a high air voids than coarse-grained soil [38].

3.5.6.3 Effect of Compaction Effort

Compactive effort is a measure of the mechanical energy imposed on the soil mass during compaction (energy per unit volume). With a soil of given moisture content, increasing the amount of compaction results in closer packing of soil particles and increased dry unit weight [39].The compaction energy per unit volume used for the Proctor test is defined as below.

$$E = \frac{\binom{\text{Number of}}{\text{blows per layer}} * \binom{\text{Number of}}{\text{layers}} * \binom{\text{Weight of}}{\text{hammer}} * (\text{Height of drop hammer})}{\text{Volume of Mold}} \quad (3.1)$$

As the compaction effort is increased, the maximum dry unit weight of compaction is increased and the optimum moisture content is decreased to some extent [39].

3.5.7 Method of Laboratory Soil Compaction

In the 1930s an American civil engineer Ralph Proctor creates compaction test. He divided compaction test into two; Standard Proctor Compaction Test (SPCT) and the Modified Proctor Compaction Test (MPCT). In Standard proctor compaction test (ASTM D 698 or AASHTO T-99), a soil at selected water content is placed in three layers in to a mould of 101.6mm diameter with each layer compacted by 25 blows of a 2.5kg hammer dropped from a height of 305mm, subjecting the soil to a total compaction effort of about 600KN/m^2. So that the resulting dry unit weight at optimum water content is determined [39]. In the case of Modified proctor compaction test (ASTM D 1557 or AASHTO T-180) test method covers laboratory compaction procedures used to determine the relationship between water content and dry unit weight of soils, compacted in 5 layers by 152.4mm diameter mould with a 4.5kg hammer dropped from a height of 457mm producing a compaction effort of 2700KN/m^2 [39]. As outlined in the above table of summary of laboratory tests, in this research this modified standard procedure (AASHTO T-180) was followed to obtain the compaction characteristics [40].

The difference between the two methods is basically the energy generated. Modified compaction test uses higher energy than standard compaction test. In both methods, the main output is finding optimum water content and maximum dry density.

Compaction tests are performed using disturbed, prepared soils with or without additives. Normally, soil retained on the no.4 (4.75mm) and passing 19mm sieve is mixed with water to form samples at various moisture contents ranging from the dry state to wet state. These samples are compacted in layers in a mold by a hammer in accordance with specified nominal compaction energy. Dry density is determined based on the moisture content and the unit weight of compacted soil. In a moisture-density relationship a compaction curve which gives the relationship between the water contents and dry densities of soil is plotted using dry density versus moisture content. From the plotted curve of dry density versus moisture content, the maximum ordinate on this curve is referred to as the maximum dry density (γdmax), and the water content at which this dry density occurs is termed as the optimum moisture content (OMC). That is at the peak of the curve, the water content is called optimum water content, and the dry density soil is called maximum dry density (MDD).

3.5.8 California Bearing Ratio (CBR) Test Methods

The CBR test was originally developed by the California Division of Highways in the 1930s, as part of a study of pavement failures. Its purpose was to provide an assessment of the relative stability of fine crushed rock base materials. The test has been modified since then and extended to subgrades. It is now widely used for evaluating the stability or strength of subgrade soil and other flexible pavement materials for pavement design throughout the world. The California Bearing Ratio (CBR) test can be performed either in the laboratory or in the field. All most both of them are similar to each other but the only difference is the type of sample, the apparatus to be used and soaking condition. The former one used typically with a compacted (disturbed) sample and may be performed either soaking or unsoaking based on the soil type and the condition of the site, and the later one used for undisturbed soil sample.

3.5.8.1 Laboratory California Bearing Ratio (CBR) Test

Laboratory CBR test is carried out as per the procedure outlined in AASHTO T193-93 or ASTM D 1883-73. This test method provides the determination of the CBR of a material at optimum water content or a range of water content from a specified compaction test and a specified dry unit weight. The dry unit weight is usually given as a percentage of maximum dry density from the compaction tests of either standard proctor test (ASTM D 698 or AASHTO T-99) or modified proctor test (ASTM D 1557 or AASHTO T-180). For this research, the Laboratory CBR test of the collected samples was carried out as per the procedures outlined in AASHTO T193-93.

In this test, a plunger is made to penetrate the soil, which is compacted to the prevalent dry density and moisture content anticipated in the field (or to MDD and OMC as specified) in a standard mold (CBR mold) at a specified rate of penetration. The resulting load-penetration curve is compared with that obtained for a standard crushed rock material, which is considered an excellent base course material.

Penetration testing is accomplished in a compression CBR machine applying the load applied by cylindrical metal plunger of 50 mm diameter, using the standard penetration rate

1.27mm/minute and readings of the applied load are taken at appropriate intervals of penetration (0.64mm, 1.27mm) up to a total penetration of usually not more than 7.62 mm-12.7mm [41].

The penetration resistance load is then plotted against the penetration depth. The CBR values is then determined by reading from the load versus penetration graph. The CBR is then determined by reading off from the curve the load that causes a penetration of 2.54 mm and 5.08mm and dividing this value by the standard load (13.4kN) and (20kN) required to produce the same penetration respectively in the standard crushed stone as [41]:

$$CBR(\%) = \frac{Unit\ load\ \ for\ 2.54/5.08\ mm\ penetration\ in\ test\ specimen}{Unit\ load\ \ for\ 2.54/5.08\ mm\ penetration\ in\ s\tan dard\ crushed\ roack} \times 100$$

(3.2)

Using the above formula, from the load-penetration curve for 2.54 mm and 5.08 mm penetration, the bearing ratio is calculated by dividing the corrected load by the corresponding standard load, multiplied by 100. Its value ranges from 0 (worst) to 100 (best). The CBR value normally reported based on the load ratio for a penetration of 2.54mm, if the bearing ratio of 2.54 mm is greater than that of 5.08 mm. However, if the ratio at 5.08 mm penetration is greater, the test is entirely repeated on a fresh specimen. If the repeated result of 5.08 mm is again greater, the design bearing ratio will be that of 5.08 mm or if the bearing ratio of 2.54 mm is greater the design bearing ratio will be that of 2.54 mm penetration [41]. In case of subgrade material 2.54mm and 5.08mm are considered as failure point of soil. In the laboratory test, if the soil sample is remolded using 56 blows per layer a single density and moisture content will be calculated, and the design CBR value will be the one that obtained at 100% of the maximum dry density obtained from compaction test. Whereas in the case of when a sample compacted at 10,30 and 65 blows per layer in different mold, the design CBR value is obtained at a desired density between a range of 95% (for lower) to 98% (for higher) of the maximum dry density obtained from compaction test in comparison to the 100% compaction achieved in the laboratory. After getting the bearing ratio for each sample, density versus CBR curve is plotted and the design CBR value of the soil will be the one corresponding to the desired dry density from the Density-CBR plot. The later approach is more practiced in different specifications and also the current research has followed this testing procedure.

According to AASHTO T 193-93 the Values of Standard force-penetration relationships for crushed stone to use in equation 3.2 are listed in Table 3.4 below [41].

Table 3.4: Penetration corresponding to standard unit load applied to standard crushed rock

Penetration (mm)	Standard unit load (MPa)
2.54	6.9
5.08	10.3
7.62	13.1
10.16	15.9
12.7	17.9

3.5.8.2 Soaking Samples and Subgrade Volume Change Classification

A subgrade strength criteria may be satisfied, but may not be adequate for volume change criteria, which must be assessed separately [42]. This is done depending upon the prevailing climatic conditions of the site. The compacted specimens are immersed in water for four days before the penetration test with a surcharge load not less than 4.52 kg that is a representative of the pavement weight in the field and applied to simulate the effect of pavement overburden stress. The soaking process is to simulate the worst moisture condition of the soil that may occur in the field. During this period, the sample is loaded with a surcharge load that simulates the estimated weight of pavement layers over the material tested. Any swell due to soaking is also measured. The test on soaked sample accomplishes two things: i) it gives information concerning expected soil expansion beneath the pavement when the soil becomes saturated. ii) It gives an indication of strength loss from field saturation [42]. The soaked CBR swell provides a better indicator of movement potential for design purposes. This is because of Swell amount provides a better indicator of movement potential or subgrade volume change due to the worst condition in the field. The percent swell is computed as dividing the change in length of specimen after four days of soaking for the initial height of specimen. Therefore, for design purposes maintaining proper drainage facility is recommended depending on this swelling condition. The subgrade volume change based on the swell amount is given as the following table.

Table 3.5: Subgrade volume change classification based on the swell condition [42]

Swell amount (%)	Subgrade volume change	Remarks
< 1	Very low	Generally acceptable
1-2	Low	Applicable providing suitable capping layers
2-3	Medium	Design for some subgrade volume change
3-5	High	Unsuitable for subgrade directly below pavements
> 5	Very high	Should be removed and replaced or stabilized

3.5.8.3 In-Situ California Bearing Ratio (CBR) Test

The in-situ CBR test is carried out as per the procedure outlined in ASTM D 4429-93. Just like Laboratory CBR test, Field in-place CBR test is used for evaluation and design of flexible pavement components such as base and sub base course and subgrades and for other applications (such as unsurfaced roads) for which CBR is the desired strength parameter.

Benkelman beam deflection measurement apparatus is used to carry out in situ CBR tests in the field on exposed subgrades, subbases, and bases. Such testes can be useful in investigating pavement failures and also in examining the performance of existing roads in good condition. Accompanied by measurements of field densities and moisture conditions, such testing provides a useful means of building up knowledge of appropriate pavement design criteria for local soils under the locally prevailing climatic conditions.

If the field CBR is to be used directly for evaluation or design without consideration for variation due to change in water content, the test should be conducted under one of the following conditions: (i) when the degree of saturation (percentage of voids filled with water) is 80 % or greater, (ii) when the material is coarse grained and cohesion less so that it is not significantly affected by changes in water content, or (iii) when the soil has not been modified by construction activities during the two years preceding the test [43].

3.6 Procedures for Correlation and Regression Analysis

3.6.1 Sample size determination

Determination of sample size is used to select representative sample from the selected study area. To calculate the required sample size, parameters such as the level of confidence interval, level of significance, standard deviation (SD) and the degree of precision which define the Margin Rate Error (MRE) need to be considered. The standard deviation of population found from previous researches and literatures. Level of confidence interval is used to indicate the reliability of an estimate. The calculation is worked firstly by selection of the desired confidence level, because all parameters involved in the formula decided depending on the level of confidence interval except the standard deviation [29].

To determine or fix the sample size, if the standard deviation of the population known, the following formula is used [29].

$$N=\left(\frac{SD}{SE}\right)^2 \qquad (3.3)$$

Where SE is standard error which given as: SE = $\frac{MRE}{Z}$, and substituting in the above formula the following formula obtained.

$$N = \frac{Z^2 * SD^2}{MRE^2} \quad (3.4)$$

If the population is unknown, the following formula is used to determine sample size for sample proportion [29].

$$N = \frac{Z * \overline{\rho}\ (1-\overline{\rho}\ )}{MRE^2} \quad (3.5)$$

Where: SD =standard deviation

MRE = Margin of error rate

$\overline{\rho}$ = percentage picking a choice or population proportion response

Z= the probability that a sample will fall within a certain distribution at a given of confidence level. For instance: Z= 1.96 at 95% of confidence level

N=sample size

3.6.2 Scatter Plots

The scatter diagrams provide a visual method of displaying a relationship between dependent and independent variables as plotted in a two dimensional coordinate system. In developing correlations, a first step is creating a scatter plot of the data obtained, to visually assess the strength and form of some type of relationship [44]. If all points in the scatter plot are very close to each other, a fairly good correlation can be expected between the dependent and independent variables. Likewise, if those points are widely scattered, a poor correlation of data can be expected between them. If the points are scattered and they reveal no upward or downward trend, then we say the variables are uncorrelated. However, if there is an increasing trend from the lower left-hand corner and going upward to the upper right-hand corner, the correlation indicated from the graph is said to be positive. Also, if there is a downward trend from the upper left-hand corner the correlation obtained is said to be negative.

3.6.3 Arranging Data entry for Correlation and Regression analysis using SPSS

To perform the analysis using the Statistical Package Software program, SPSS, setting up the data in the form of two variables (independent and dependent) using Microsoft excel (spreadsheet) is the primary criteria. Then, the arranged data imported from Microsoft excel to the SPSS software for correlation and regression [45]. Then Methods of Regression analysis is applied. In this study stepwise analysis methods is used.

Stepwise regression is an approach to identify the effects of one variable on the other for a regression model. It is a step-by-step both forward (adding parameters) and backward (reducing parameters) iterative construction of a regression model that involves automatic selection of independent variables. It interactively explores which predictors seem to provide a good fit.

3.6.4 Normality Test

Normality test is used to check whether the data fulfill assumption of normally distributed or not. There are many tests to check whether the data is normally distributed or not. These tests basically classified as graphical and non-graphical (Statistical or analytical**)** tests for assessing normality [46]. The other main thing of testing normality is to identify or to choose the methods of statistical test whether it's parametric or non-parametric test.

3.6.4.1 Graphical methods of assessing Normality test

By graphical method data does not need to be perfectly normally distributed for the tests to be reliable. However, to be the data is approximately normally distributed, the normal distribution peaks in the middle and is symmetrical about the mean [46]. Under Graphical methods there are two methods which are available in SPSS. These methods are described as the following.

Histogram Method: By this method the normality of data is checked by plotting a histogram of the variables that will give an indication of the shape the distribution. In this case the normality of the collected data is checked comparing the actual data distribution with the theoretical normal distribution which is shown by a normal approximation curve through a visual examination of the drawn curve. If the normal distribution peaks fall in the middle and fairly symmetrical and if the curve has bell-shaped, the data is considered as normally distributed, if not the data is not normally distributed [47].

Normal Q-Q Plot Method: Likewise the histogram method, Q-Q plots also used to check the normality of the given data through visual examination of the drawn line. The normal Q-Q plot is an alternative graphical methods of assessing normality to the histogram and is easier to use when there are small sample sizes. By this method the scatter should lie as close to the line as possible with no obvious pattern coming away from the line for the data to be considered normally distributed [47].

3.6.4.2 Statistical (Analytical) Methods of Normality Test

Statistical (Analytical) test for normality are more precise than the graphical method test since the actual probabilities are calculated to accept or reject the statistical hypothesis depending on the level of the probability. There are several methods of statistical tests for normality test. However, the following some techniques are considered in order to test the normality of the data. These methods are Kolmogorov - Smirnov Test, Shapiro - Wilks Test and the use of skewness and kurtosis coefficients. These methods are available in SPSS to assess the normality [45].

3.6.4.2.1 Normality Test Using Kolmogorov - Smirnov Test and Shapiro - Wilks Test

These to see whether the distribution as a whole deviates from a comparable normal distribution or not. The Kolmogorov–Smirnov test and Shapiro–Wilk test compare the scores in the sample to a normally distributed set of scores with the same mean and standard deviation. If the test is non-significant ($p > .05$) it tells us that the distribution of the sample is not significantly different from a normal distribution (i.e. it is probably normal) hence accept the null hypothesis. If, however, the test is significant ($p < .05$) then the distribution in question is significantly different from a normal distribution (i.e. it is non-normal) which lead to the rejection of the normality (null hypothesis) [45]. Kolmogorov - Smirnov Test works best for data sets more than fifty (>50). Shapiro - Wilks Test is applicable or works best for data sets with $3 < n < 50$, but can be used with larger data sets.

3.6.4.2.2 Normality Test Using Skewness and Kurtosis Coefficients

The other alternative analytical methods of measuring normality of data is comparing skewness and kurtosis values with their standard errors. The value of skewness and kurtosis are informative for deciding the normality of data. Both parameters are obtained from the SPSS output through the analysis of frequency distribution. By this test, the normality of data is identified depending on the associated standard error with the skewness and kurtosis value respectively. To determine the normality the obtained value of skewness and kurtosis should be converted or transformed to z-scores. To transform any skewness and kurtosis score to a z-score, simply divide the skewness and kurtosis value by their respective standard error produced by SPSS [45]. Therefore, skewness and kurtosis are converted to z-scores in exactly by the following way.

$$Z_{skewness} = \frac{S}{SE(Skewness)} \quad \text{and} \quad Z_{kurtosis} = \frac{K}{SE(kurtosis)} \qquad (3.6)$$

Where S is value of Skewness, K is value of kurtosis and, SE (skewness) and SE (kurtosis) are the standard error for skewness and kurtosis respectively. Then the converted value of skewness and kurtosis are compared with a critical Z-value assumed for a normally distributed sample. For normal distribution sample, for 95% confidence interval the z-scores should lie between −1.96 and +1.96 [45]. If the converted value falls within the critical Z-value assumed for normally distributed data then the data is approximately considered as normally distributed.

3.6.5 Multicollinearity (interdependency) of independent Variables Test

Multicollinearity is associated with the situation results from the presence of strong linear relationships among the predictor variables. It is exists when there is a strong correlation between two or more predictors in a regression model. If there is perfect collinearity between predictors there is a multicollinearity problem between the predictors.

3.6.5.1 Methods for Measuring Multicollinearity

There are two methods for measuring collinearity between the predictor variables. These are variance inflation factors (VIF) and correlation coefficient (R) of correlation matrix.

3.6.5.1.1 Variance Inflation Factors (VIF)

The multicollinearity (interdependency) between the predictor variables can be judged by examining a quantity called the variance inflation factor (VIF) [45]. The VIF indicates whether a predictor has a strong linear relationship with the other predictor(s). Andy Field, [45] suggests that if a value of VIF is greater than 10 then there is cause for concern of multicollinearity problem in the regression model. Related to the VIF there is the tolerance statistic which is its reciprocal (1/VIF). If the tolerance statistics is greater than 0.1, we can safely conclude that there is no collinearity within the predictor variables.

3.6.5.1.2 Correlation coefficient of correlation matrix

The other way of identifying multicollinearity in the data is to examine a correlation matrix of all of the predictor variables. Depending on the size of the correlation coefficients that exist among the predictor variables it can be detect the presence of collinearity. Andy Field, [45] Suggests that If there is no multicollinearity in the data then there should be no considerable strong correlations ($R < 0.9$) between a pair of predictors unless otherwise there is a strong correlation ($R \geq 0.9$) which indicates the presence of multicollinearity problem between a pair of predictor variables.

3.6.6 Correlation and Regression Analysis Methods

Correlation is the way of measuring the relationships between two variables. It quantifies the degree to which dependent and independent variables are related. There are two methods of statistical hypothesis for correlation. These are directional hypothesis and non-directional hypothesis. The former one is used if the level of significance one-tailed is used and the later one used for two-tailed level of significance [45].

Regression analysis provides a statistical technique for modeling and investigating the relationship between two or more variables. It is a way of predicting an outcome variable from one predictor variable (simple regression) or several predictor variables (multiple regression). As a general rule, in multiple regression the fewer predictors the better, and certainly include only predictors for which you have a good theoretical grounding (it is meaningless to measure hundreds of variables and then put them all into a regression model) [45]. A variable whose value is predicted is called the dependent variable or response. A variable used to predict the value of the dependent variable is termed independent. Various techniques can be used to indicate the adequacy of a multiple regression models. A commonly used techniques are listed and discussed as the following.

3.6.6.1 The Standard Error Statistics

The standard error of a statistic gives some idea about the precision of an estimate or predictor variable. [45] demonstrated that as samples get large (usually defined as >=30), the sampling distribution has a normal distribution with a mean equal to the population mean, and a standard deviation given by:

$$\sigma = \frac{SD}{\sqrt{N}} \tag{3.7}$$

Where: σ = estimated standard error of a sample

N = sample size

During modelling, a variable that shows the least standard error of estimates is the one to be relatively chosen because least standard error indicates there is not much variability in the sample observations.

3.6.6.2 Residual Analysis

Residual analysis is any technique that uses the residuals, usually to investigate the adequacy of the model that was used to generate the residuals. The differences between the values of the outcome predicted by the model and the values of the outcome observed experimentally in the sample are known as residuals. These residuals represent the error present in the model. If a model fits the sample data well then all residuals will be small (if the model was a perfect fit of the sample data – all data points fall on the regression line – then all residuals would be zero). If a model is a poor fit of the sample data then the residuals will be large [45].

3.6.6.3 Pearson's correlation coefficient (R)

Correlation coefficients measures the strength of linear association between two measurement variables. To overcome the problem of dependence on the measurement scale, it is need to convert the covariance into a standard set of units. This process is known as standardization, and the standardized covariance is known as a correlation coefficient or Pearson's correlation coefficient which is represented by letter R. It is calculated as using the following formula [45].

$$R = \frac{cov(x,y)}{sd(x)*sd(y)} \qquad (3.8)$$

Where: cov(x, y) $=\sum_{i=0}^{n}(x_i - \bar{x})(y_i - \bar{y})$ =covariance of x and y variable

sd(x) = $\sqrt{\sum_{i=0}^{n}(x_i - \bar{x})}$ = standard deviation of variable x

sd(y) =$\sqrt{\sum_{i=0}^{n}(y_i - \bar{y})}$ = standard deviation of variable y

The value of R ranges from -1 to +1. A coefficient of correlation +1 indicates that the two variables are perfectly positively correlated, so as one variable increases, the other increases by a proportionate amount. Conversely, a coefficient of -1 indicates a perfect negative relationship: if one variable increases, the other decreases by a proportionate amount. A coefficient of zero indicates no linear relationship at all and so if one variable changes, the other stays the same [45]. The significance of the correlation coefficient is to test the hypothesis that the correlation is different from zero (i.e. different from 'no relationship'). The following key points shows assumptions used for conducting Pearson correlation.

- The two variables should be measured at the interval or ratio level
- There needs to be a linear relationship between the two variables
- There should be no significant outliers
- The variables should be approximately normally distributed

3.6.6.4 Coefficient of Determination (R^2)

The squared correlation coefficient is known as the coefficient of determination (R^2). Coefficient of determination (R^2) is a measure of the amount of variability in one variable that is shared by the other during regression models. Computationally, large values of R^2

(near unity) is considered as good. However, it is possible to have large values of R^2 and find that the model is unsatisfactory [48]. The value of R^2 is always between 0 and 1, because R is between -1 and +1, whereby a negative value of R indicates inversely relationship and positive value implies direct relationship [49]. It is given by the equation:

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST} \quad (3.9)$$

Where: $SST = \sum_{i=1}^{n}(y - \bar{y})^2$

$SSE = \sum_{i=1}^{n}(y_i - \bar{y}_i)$

And $SSR = SS_T - SS_E$ = regression sum of squares

SS_E = error sum of squares or residual sum of squares

SS_T = total sum of squares

yi = i^th^ value of the response variable

$\bar{y}i$ = i^th^ value of the fitted response variable.

$\bar{y}$ = average value of the response variable.

From the above equation, the value of total sum of squares (SST) represents how good the mean is as a model of the observed data. The value of residual or error sum of squares (SSE) represents the degree of inaccuracy when the best model is fitted to the data. The value of regression sum of squares (SSR) is the difference between the value of total sum of squares (SST) and the value of residual or error sum of squares (SSE), and shows the reduction in the inaccuracy of the model resulting from fitting the regression model to the data. If the value of SSR is large then the regression model is very different from using the mean to predict the outcome variable. This implies that the regression model has made a big improvement to how well the outcome variable can be predicted. However, if SSE is small then using the regression model is little better than using the mean [45].

3.6.6.5 Adjusted R^2

Another useful criterion used to check the adequacy of a regression model is using a adjusted R^2 that accounts the usefulness of a variable in a model. This adjusted value indicates the loss of predictive power or shrinkage. The adjusted value tells how much variance in the outcome would be accounted for if the model had been derived from the population from which the sample was taken [45]. It also gives some idea of how well the model generalizes and ideally its value to be the same or very close to the value of R^2. The Stein’s formula was given as below to calculate the adjusted coefficient of determination, R^2 (adj.) [45].

$$R^2 \text{ (adj.)} = 1\text{-}\left[\left(\frac{n-1}{n-k-1}\right)\left(\frac{n-2}{n-k-2}\right)\left(\frac{n+1}{n}\right)\right](n - R^2) \quad (3.10)$$

Where: k = number of predictors in the regression model

n = Sample size

R^2 (adj.) = adjusted coefficient of determination

. R^2 = coefficient of determination

Maximizing the value of R^2 by adding variables is inappropriate unless variables are added to the equation for sound theoretical reason. At an extreme, when n-1 variables are added to a regression equation, R^2 will be 1, but this result is meaningless. Adjusted R^2 is used as a conservative reduction to R^2 to penalize for adding variables and is required when the number of independent variables is high relative to the number of cases or when comparing models with different numbers of independents [50].

3.6.7 Parametric Statistical Test

We cannot really talk about the strength of a relationship indicated by the correlation coefficient only without testing a statistical test of significance. Hence a statistical test of significance should be tested to decide the relationship between the parameters. A parametric statistical test provides a mechanism for making qualitative decisions about a process generally based on the assumption that the data follows a normal distribution. The intent is to determine whether there is enough evidence to “reject” a null hypothesis or hypothesis about the process. Not rejecting may be a good result if we want to continue to act as if we “believe” the null hypothesis is true. Or it may be a disappointing result, possibly indicating we may not yet enough data to “prove” something by rejecting the null hypothesis [51].

Several problems in engineering require that decision whether to accept or reject a statement about the relationship between the dependent (outcome) and the independent (predictor) variables to be studied [29]. The statement is called a hypothesis, and the decision making procedure about the hypothesis is called hypothesis testing. A hypothesis is a kind of truth claim about some aspect of the world. This is one of the most useful aspects of statistical inference or implication. Statistical inference is to assess the extent to which the findings of a study can be accepted as valid for the population from which the study sample has been drawn [29].

To test the validity of a Statistical hypothesis; the following two hypothesis can be formulated as follows:

$H_{0:}\ \mu = 0$

$H_1\!: \mu \neq 0$ (3.11)

Where "Ho "and "H_1" are the null hypothesis and alternative hypothesis respectively for an arbitrary population value of μ. The following are some of parametric statistical hypothesis methods used to accept or reject a given hypothesis in regression model.

3.6.7.1 The Analysis of Variance (ANOVA) Test

ANOVA test is a test of statistical significance for assessing the difference between two or more sample means. ANOVA test is used to test a regression model to determine if one or more of the means of several groups is different from others. The ANOVA tells us whether the model overall results in a significantly good degree of prediction of the outcome variable. The fit of the regression model can be assessed using the Model Summary and ANOVA tables from SPSS. The ANOVA also tells us whether the model is a significant fit of the data overall for values less than .05 in the column labelled Sig. The test statistic for ANOVA is called the F-ratio which is described as below [51]. Finally, there is an assumption that errors in regression are independent; this assumption is likely to be met if the Durbin–Watson statistic is close to 2 (between 1 and 3) [45].

3.6.7.2 The F-ratio Test

F-statistic test is test used to test the role of all variables in explaining the variation in the dependent variable. The F-ratio represents the ratio of the improvement in prediction that results from fitting the model relative to the inaccuracy that still exists in the model. It is the statistical parameters used as criteria to select the best fit model among the predicted models. The F-ratio is calculated by dividing the average improvement in prediction by the model (MSR) by the average difference between the model and the observed data which is mean square error or residual (MSE). The average sum of squares (MS) is calculated for each term by dividing the SS by their respective degree of freedom (df) [45].

$$\text{F-ratio} = \frac{\text{Mean Square Regression}}{\text{Mean Square Error or Residual}} = \frac{\text{MSR}}{\text{MSE}} = \frac{\frac{\text{SSR}}{\text{df of SSR}}}{\frac{\text{SSE}}{\text{df of SSE}}} \qquad (3.12)$$

If the improvement due to fitting the regression model is much greater than the inaccuracy within the model then the value of F will be much greater than 1. Hence based on the value of F–ratio value we can interpret that the model with better F value significantly improves the ability to predict the outcome variable if the significant value labelled with it is less than 0.05 [45].

3.6.7.3 The t-test

The t-test is a very versatile statistic. The t-statistic is the test used to test the role of a single variable in explaining the variation in the dependent variable. It can be used to test whether a correlation coefficient is different from 0, it can also be used to test whether a regression coefficient b is different from 0. In multiple regression, the easiest to conceptualize the t-tests measures whether the predictor is making a significant contribution to the model. A significant value of t indicates that the slope of the regression line is significantly different from horizontal which implies a b-value is significantly different from 0. Therefore, if the t-test associated with b-value is significant (if the value in the column labelled Sig.is less than .05) then the predictor is making a significant contribution to the model. The smaller the value of Significance and the larger the value of t-value indicate the greater the contribution of that predictor in the model. The t-value is simply calculated as:

$$t_{\text{value}} = \frac{\text{B}}{\text{SE(B)}} = \frac{\text{Coefficient of a variable in the regression equation}}{\text{Standard error of the estimated coefficient}} \qquad (3.13)$$

3.6.7.4 Test of Significance Level

In linguistic, “significant" means important, while in Statistics "significant" means probably true [48]. When statisticians say a result is "highly significant" they mean it is very probably true. They do not (necessarily) mean it is highly important. The most common level used to mean something is good enough to be believed is 95%. This means that the finding has a 95% chance of being true which also means that the finding has a confidence degree 95% of being true and the finding has a five percent (.05) chance of not being true or error, which is the converse of a 95% chance of being true [48].

In statistical analysis, the significance level (α) "alpha level" for a given hypothesis test is a value for which a P-value "calculated value" less than or equal to α is considered statistically significant. This means If p-value is smaller than α (<0.05), the particular variable is important (significant) in explaining the variation of the response in the model. Conversely, a larger p-value (>0.05) suggests that changes in the predictor are not associated with changes in the response in the model. The typical value of levels of significance (α) are 0.1, 0.05, and 0.01. These value levels correspond to the probability of observing such an extreme value by chance. For example, if the P-value is 0.0082, the probability of observing such a value by chance is less than 0.01, and the result is significant at the 0.01 level [48]. Nowadays, commercial statistical software such as SPSS can provide p-values. Hence, we may not need statistical tables for our particular decision.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Laboratory Test Result

Based on the sample collected from different location of the study area, in order to characterize some engineering properties of soils found in the study area, different laboratory tests were conducted on the thirty samples in the Geotechnical Engineering Laboratory Test of Jimma University, Jimma Institute of Technology. The sample were tested for different parameters conducting laboratory tests listed as the following one.

- Natural Moisture Content
- Specific Gravity
- Grain Size Distribution Analysis (Wet Sieve Analysis)
- Atterberg's Limits Test
- Compaction Test,(Modified Proctor Compaction Test)
- California Bearing Ratio Test, (Three-Point CBR Test)

The final test result obtained from each sample is presented here in this chapter, and also for the sake of illustration some tables and figures of the laboratory test result of the typical sample is presented in this part. But the whole laboratory analysis and test result obtained from each sample is attached to Appendix I to N of this thesis.

4.1.1 Natural Moisture Content

The Natural Moisture Content of the soil sample is the mass of water which can be removed from the soil by heating (oven drying) at 100 ^{0}C to 110 ^{0}C expressed as percentage of the dry mass. The Natural moisture content of the soil of the study area is varied from the range of 36.7% to 42.8%. For the sake of illustration typical table is presented under appendix I of this thesis to determine the natural moisture content of the sample and the value of all samples is presented in the summary of all laboratory test result (table 4.6) of this thesis.

4.1.2 Specific Gravity

The specific gravity of soil solid is the mass density of the mineral solids in the soil normalized relative to the mass density of water. The specific gravity of the soil of the study area is varied from the range of 2.65 to 2.72. For the sake of illustration typical table is presented under appendix J of this thesis to determine the specific gravity of the sample and the value of all samples is presented in the summary of all laboratory test result (table 4.6) of this thesis.

4.1.3 Grain Size Distribution

The result of the sieve (Wet Sieve) analysis of the soil of the study area is shown in the following table and figure below, and the individual analysis of all samples are presented under Appendix K of this thesis.

Table 4.1: Grain Size (Wet Sieve) Analysis Laboratory Test Result

Test Pits	Depth (m)	Sieve Size (mm) and Percent Passing (%)			Percent amount of Particle Size						Type of Soil
					AASHTO			USCS			
		4.75 mm	2 mm	0.075 mm	Gravel	Sand	Silt and Clay	Gravel	Sand	Silt and Clay	
TP1	1	100	99.2	87.5	0.76	11.70	87.54	0	12.46	87.54	Fine grained
	2	100	99.7	84.2	0.28	15.50	84.22	0	15.78	84.22	Fine grained
	3	100	99.2	82.6	0.82	16.58	82.60	0	17.40	82.60	Fine grained
TP2	1	100	98.8	89	1.16	9.68	89.16	0	10.84	89.16	Fine grained
	2	100.0	98.8	85.8	1.18	13.06	85.76	0.00	14.24	85.76	Fine grained
	3	99.7	98.4	76.5	1.64	21.82	76.54	0.30	23.16	76.54	Fine grained
TP3	1	99.7	98.7	78.4	1.30	20.34	78.36	0.34	21.30	78.36	Fine grained
	2	99.4	97.4	76.4	2.60	20.98	76.42	0.62	22.96	76.42	Fine grained
	3	99.2	97.3	74.8	2.72	22.44	74.84	0.78	24.38	74.84	Fine grained
TP4	1	100	99.5	82.8	0.54	16.62	82.84	0	17.16	82.84	Fine grained
	2	100	99.4	81.1	0.58	18.28	81.14	0	18.86	81.14	Fine grained
	3	100	99.3	78.4	0.74	20.82	78.44	0	21.56	78.44	Fine grained
TP5	1	99.8	99.3	82.8	0.66	16.50	82.84	0.16	17.00	82.84	Fine grained
	2	99.7	99.0	81.2	0.98	17.84	81.18	0.26	18.56	81.18	Fine grained
	3	99.5	98.2	80.7	1.82	17.44	80.74	0.50	18.76	80.74	Fine grained
TP6	1	99.7	99.2	86.4	0.78	12.78	86.44	0.26	13.30	86.44	Fine grained
	2	99.7	99.0	84.8	0.98	14.22	84.80	0.34	14.86	84.80	Fine grained
	3	99.6	98.8	80.1	1.20	18.70	80.10	0.42	19.48	80.10	Fine grained
TP7	1	99.9	99.6	81.7	0.40	17.92	81.68	0.08	18.24	81.68	Fine grained
	2	99.6	98.5	81.4	1.54	17.10	81.36	0.36	18.28	81.36	Fine grained
	3	99.5	98.2	78.3	1.80	19.90	78.30	0.46	21.24	78.30	Fine grained
TP8	1	100	99.6	84.6	0.42	15.02	84.56	0	15.44	84.56	Fine grained
	2	100	99.5	81.9	0.48	17.62	81.90	0	18.10	81.90	Fine grained
	3	100	99.5	79.7	0.48	19.80	79.72	0	20.28	79.72	Fine grained
TP9	1	100	99.1	90.7	0.86	8.48	90.66	0	9.34	90.66	Fine grained
	2	100	99.3	84.9	0.72	14.40	84.88	0	15.12	84.88	Fine grained
	3	100	98.6	80.4	1.36	18.22	80.42	0	19.58	80.42	Fine grained
TP10	1	100	100.0	88.2	0.04	11.76	88.20	0	11.80	88.20	Fine grained
	2	100	99.6	86.9	0.42	12.66	86.92	0	13.08	86.92	Fine grained
	3	100	99.9	86.1	0.13	13.78	86.09	0	13.91	86.09	Fine grained

The Grain Size Distribution Curve of all Samples is shown as figure 4.1 and 4.2 below.

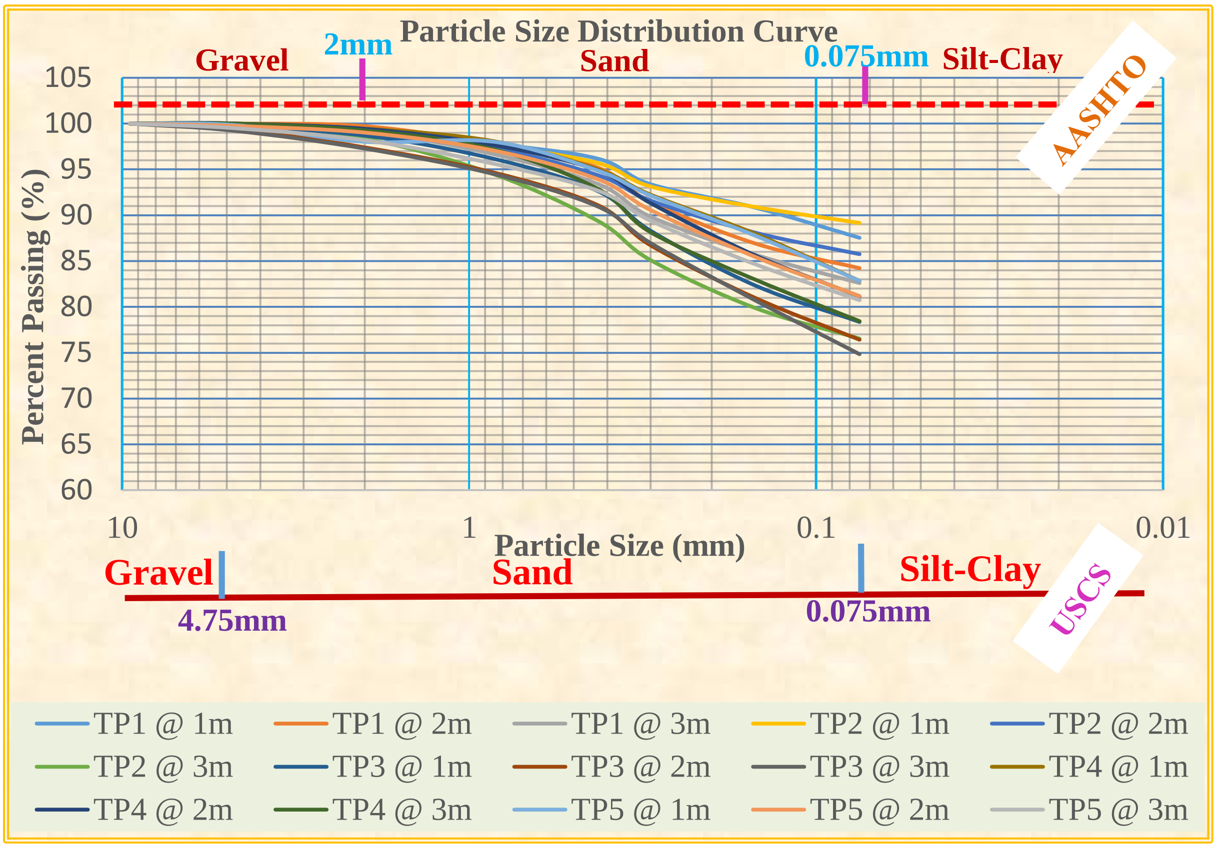


Figure 4.1: Grain Size Distribution Curve of Soil Samples (TP-1 to TP-5)

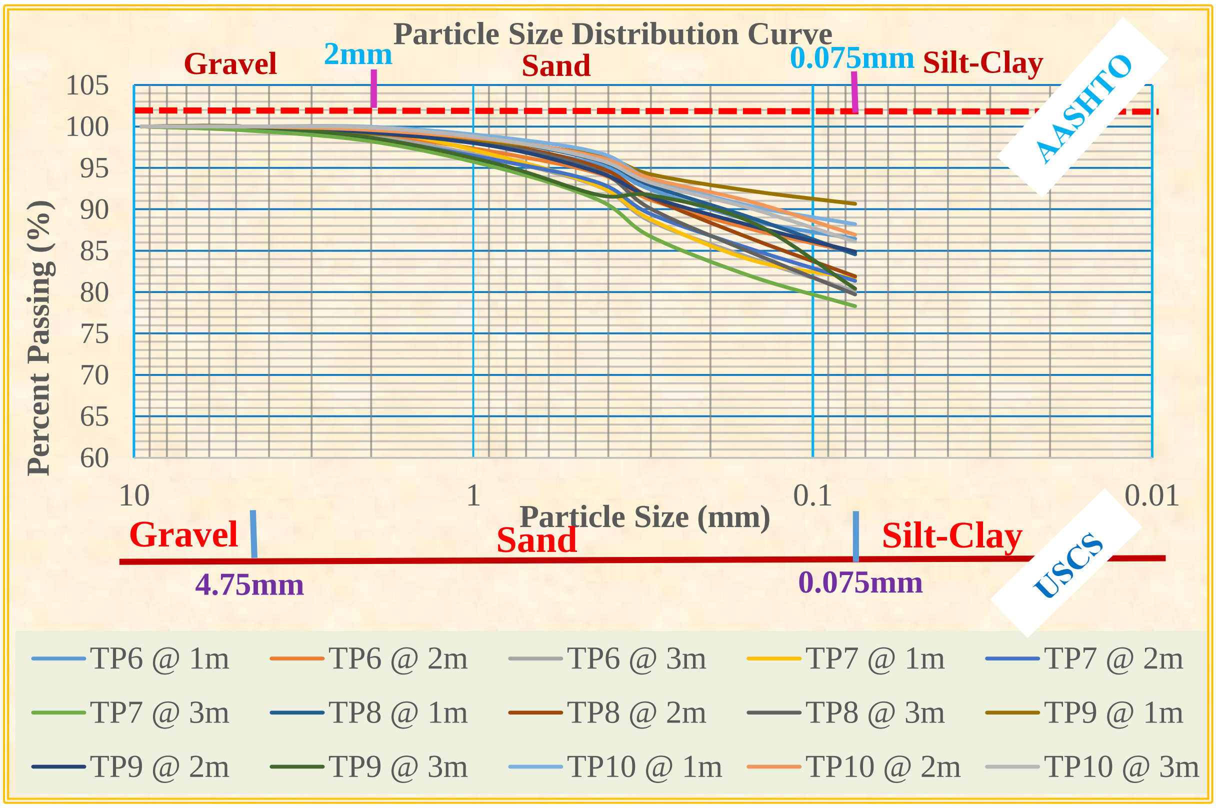


Figure 4.2: Grain Size Distribution Curve of Soil Samples (TP-6 to TP-10)

4.1.4 Atterberg's Limits Laboratory Test Result

The Atterberg's Limits (LL, PL and PI) of the Soil of the study area is varied from (46 to 76, 27.9 to 44.6 and 17.8 to 35.6) % respectively. The result of the Atterberg's Limits of all samples is shown in the following table, and the detail analysis of all samples is presented under Appendix L of this thesis.

Table 4.2: Atterberg's Limits Laboratory Test Result

Test Pits	Sample Depth (m)	Atterberg Limits Test Result		
		LL (%)	PL (%)	PI (%)
TP1	1	60.8	32.5	28.3
	2	56.4	30.2	26.2
	3	53.6	29.8	23.8
TP2	1	70.8	36.4	34.4
	2	67.6	38.4	29.2
	3	64.9	36.4	28.5
TP3	1	49.6	29.9	19.7
	2	48.4	29.8	18.6
	3	46.8	27.9	18.9
TP4	1	71.2	44.6	26.6
	2	73.5	44.3	29.2
	3	69.4	39.4	30.0
TP5	1	69.6	38.8	30.8
	2	66.6	37.3	29.3
	3	60.2	32.6	27.6
TP6	1	60.8	33.4	27.4
	2	50.0	29.4	20.6
	3	46.0	28.2	17.8
TP7	1	70.0	42.1	27.9
	2	68.0	37.3	30.7
	3	48.5	28.8	19.7
TP8	1	64.4	34.6	29.8
	2	60.8	32.4	28.4
	3	57.5	31.4	26.1
TP9	1	74.0	42.5	31.5
	2	73.0	41.6	31.4
	3	66.6	35.4	31.2
TP10	1	76.0	40.4	35.6
	2	74.8	41.2	33.6
	3	73.0	41.5	31.5

For the sake of illustration the following typical flow curve is shown to determine the liquid limit of the sample.

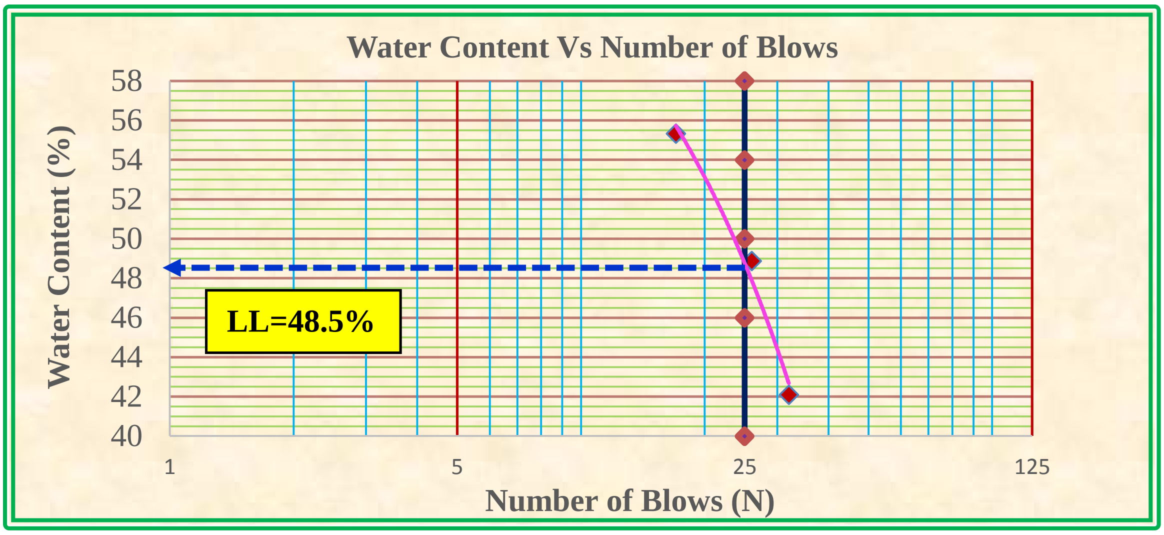


Figure 4.3: Typical Flow Curve of Soil Sample (TP7 @ 3m)

4.1.5 Soil Classification

The soil classification of the soil of the study area is performed according to USCS and AASHTO classification system depending on Sieve analysis (Percent Passing sieve no.200) and Atterberg Limits test result (LL and PI). This classification is shown in the following figure depending on both AASHTO and USCS plasticity chart.

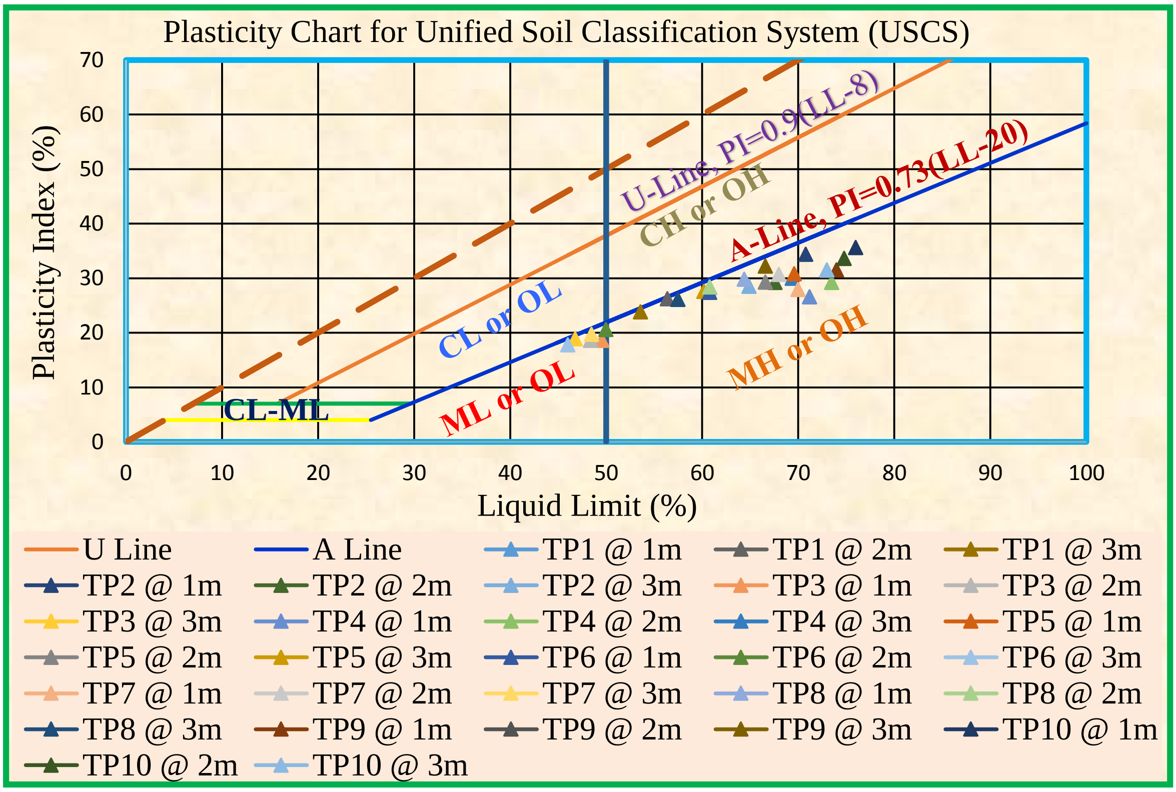


Figure 4.4: Plasticity Chart for Unified Soil Classification System (USCS)

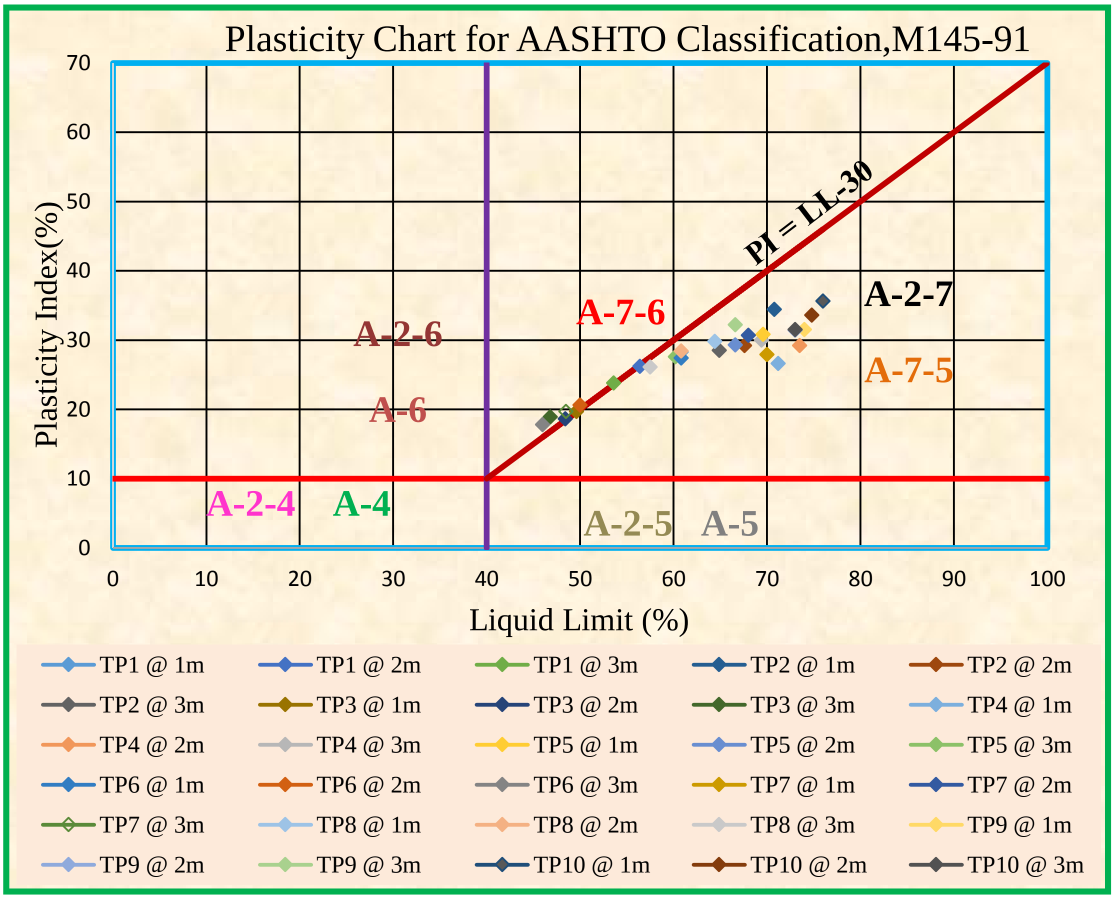


Figure 4.5: Plasticity Chart for AASHTO Classification, M145-91

4.1.5.1 Discussion on the Soil Classification

From the obtained laboratory test result, the region in which the point of Plasticity index and Liquid limit falls indicates that the soil of the study area is classified as high plastic and low plastic fine grained soil. According to the two system of soil classification, USCS and AASHTO classification system, taking the studied samples as a representative of the soil in the study area, 20% of the soil of the study area is classified as low-plasticity (ML) and 80% of the soil of the study area is classified as high-plasticity (MH) fine-grained soil. The group symbol and group classification for USCS and AASHTO is expressed as (ML and MH), and (A-7-6 and A-7-5) respectively. In the case of Unified Soil Classification System (USCS) the soil is classified as Silt-Clay soil. In the case of AASHTO classification system the soil is classified as clayey soil.

Furthermore, based on both the above mentioned Plasticity Chart (USCS and AASHTO), and material passing through sieve number 200 (0.075mm) the Soil of the Study area is classified and shown in the following table.

Table 4.3: Soil Classification of the Study area according to USCS and AASHTO classification system

Test Pits	Depth (m)	PP200	Atterberg's Limits Test Result			According to Plasticity Chart			Group Index (GI)	Soil Classification System	
						USCS		AASHTO			
			LL (%)	PL (%)	PI (%)	U-Line	A-Line	PI = LL-30		AASHTO	USCS
TP1	1	87.5	60.8	32.5	28.3	47.5	29.8	30.8	29	A-7-5(29)	MH
	2	84.2	56.4	30.2	26.2	43.6	26.6	26.4	25	A-7-5(25)	MH
	3	82.6	53.6	29.8	23.8	41.0	24.5	23.6	22	A-7-6(22)	MH
TP2	1	89.2	70.8	36.4	34.4	56.5	37.1	40.8	37	A-7-5(37)	MH
	2	85.8	67.6	38.4	29.2	53.6	34.7	37.6	31	A-7-5(31)	MH
	3	76.5	64.9	36.4	28.5	51.2	32.8	34.9	25	A-7-5(25)	MH
TP3	1	78.4	49.6	29.9	19.7	37.4	21.6	19.6	17	A-7-6(17)	ML
	2	76.4	48.4	29.8	18.6	36.4	20.7	18.4	15	A-7-6(15)	ML
	3	74.8	46.8	27.9	18.9	34.9	19.6	16.8	15	A-7-6(15)	ML
TP4	1	82.8	71.2	44.6	26.6	56.9	37.4	41.2	28	A-7-5(28)	MH
	2	81.1	73.5	44.3	29.2	59.0	39.1	43.5	30	A-7-5(30)	MH
	3	78.4	69.4	39.4	30	55.3	36.1	39.4	28	A-7-5(28)	MH
TP5	1	82.8	69.6	38.8	30.8	55.4	36.2	39.6	31	A-7-5(31)	MH

	2	81.2	66.6	37.3	29.3	52.7	34.0	36.6	28	A-7-5(28)	MH
	3	80.7	60.2	32.6	27.6	47.0	29.3	30.2	25	A-7-5(25)	ML
TP6	1	86.4	60.8	33.4	27.4	47.5	29.8	30.8	28	A-7-5(28)	MH
	2	84.8	50	29.4	20.6	37.8	21.9	20.0	20	A-7-6(20)	MH
	3	80.1	46	28.2	17.8	34.2	19.0	16.0	15	A-7-6(15)	ML
TP7	1	81.7	70	42.1	27.9	55.8	36.5	40.0	28	A-7-5(28)	MH
	2	81.4	68	37.3	30.7	54.0	35.0	38.0	30	A-7-5(30)	MH
	3	78.3	48.5	28.8	19.7	36.5	20.8	18.5	17	A-7-6(17)	ML
TP8	1	84.6	64.4	34.6	29.8	50.8	32.4	34.4	30	A-7-5(30)	MH
	2	81.9	60.8	32.4	28.4	47.5	29.8	30.8	27	A-7-5(27)	MH
	3	79.7	57.5	31.4	26.1	44.6	27.4	27.5	23	A-7-5(23)	MH
TP9	1	90.7	74	42.5	31.5	59.4	39.4	44.0	37	A-7-5(37)	MH
	2	84.9	73	41.6	31.4	58.5	38.7	43.0	33	A-7-5(33)	MH
	3	80.4	66.6	34.4	32.2	52.7	34.0	36.6	30	A-7-5(20)	MH
TP10	1	88.2	76	40.4	35.6	61.2	40.9	46.0	39	A-7-5(39)	MH
	2	86.9	74.8	41.2	33.6	60.1	40.0	44.8	36	A-7-5(36)	MH
	3	86.1	73	41.5	31.5	58.5	38.7	43.0	34	A-7-5(34)	MH

4.1.6 Moisture-Density Relationship

The Moisture-Density Relationship parameters (Compaction characteristics), Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the soil in the study area is varied from 26.2% to 35.6% and 1.37 g/cc to 1.54 g/cc respectively.

For the sake of illustration the following typical Moisture-Density Curve is shown to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the soil sample, and the detail analysis of all samples is presented under Appendix M of this thesis.

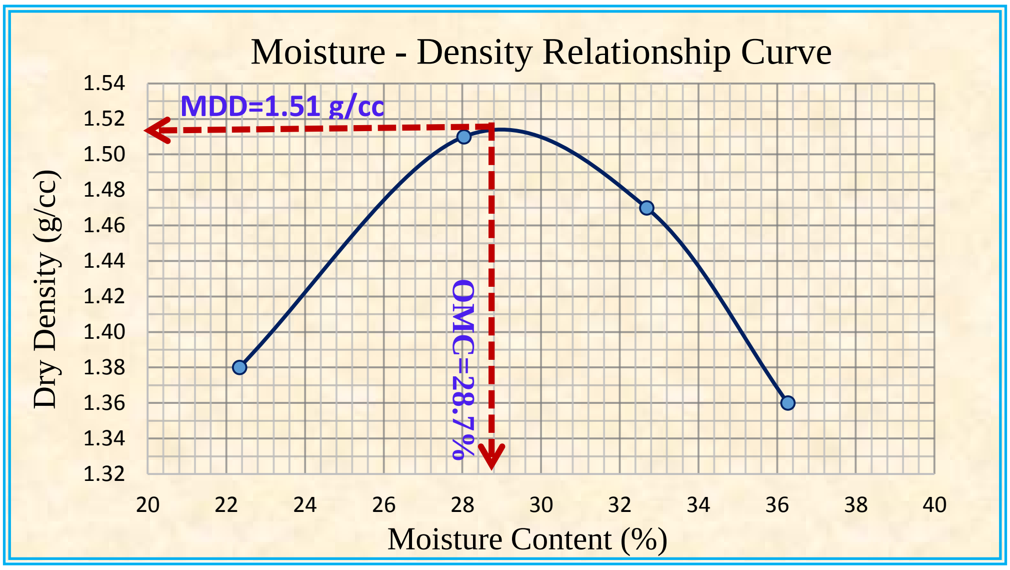


Figure 4.6: Typical Moisture-Density Relationship Curve of Soil Sample (TP7 @ 3m)

4.1.7 California Bearing Ratio (CBR) Value

The California Bearing Ratio (CBR) Value of the Soil of the study area is varied from 3.4% to 12.8%. The result of the Moisture-Density Parameters (Compaction characteristics) and California Bearing Ratio (CBR) value of all samples is shown in the following table.

Table 4.4: Modified Proctor Compaction and CBR Laboratory Test Result

Test Pits	Depth (mm)	Modified Proctor Test Result		California Bearing Ratio (CBR) Test Result										
				Target Density	No. of Blows	Density (g/cc)	Load of Specimen(kN)		Standard Load (kN)		CBR Value		Larger CBR Value	CBR @ 95% MDD
		OMC (%)	MDD (g/cc)	95% MDD			@ 2.54 mm	@ 5.08 mm	@ 2.54 mm	@ 5.08 mm	@ 2.54 mm	@ 5.08 mm		
TP1	1	32.7	1.46	1.39	10	1.31	0.69	0.97	13.2	20	5.2	4.9	5.2	7
					30	1.38	0.881	1.205	13.2	20	6.7	6.0	6.7	
					65	1.43	1.124	1.468	13.2	20	8.5	7.3	8.5	
	2	32.5	1.45	1.38	10	1.17	0.358	0.424	13.2	20	2.7	2.1	2.7	7.4
					30	1.35	0.861	1.151	13.2	20	6.5	5.8	6.5	
					65	1.45	1.33	1.588	13.2	20	10.1	7.9	10.1	
	3	28.8	1.5	1.43	10	1.29	0.483	0.692	13.2	20	3.7	3.5	3.7	8
					30	1.47	1.26	1.762	13.2	20	9.5	8.8	9.5	
					65	1.52	1.702	2.197	13.2	20	12.9	11.0	12.9	
TP2	1	32.3	1.48	1.41	10	1.23	0.251	0.323	13.2	20	1.9	1.6	1.9	6.4
					30	1.37	0.702	1.001	13.2	20	5.3	5.0	5.3	
					65	1.54	1.392	1.929	13.2	20	10.5	9.6	10.5	
	2	31.5	1.49	1.42	10	1.22	0.558	0.744	13.2	20	4.2	3.7	4.2	7.6
					30	1.46	1.125	1.411	13.2	20	8.5	7.1	8.5	
					65	1.63	1.578	2.028	13.2	20	12.0	10.1	12.0	
	3	30.3	1.49	1.42	10	1.23	0.543	0.613	13.2	20	4.1	3.1	4.1	8.2
					30	1.38	0.98	1.353	13.2	20	7.4	6.8	7.4	
					65	1.56	1.386	1.801	13.2	20	10.5	9.0	10.5	
TP3	1	27.5	1.51	1.43	10	1.26	0.845	1.165	13.2	20	6.4	5.8	6.4	10.5
					30	1.41	1.334	1.702	13.2	20	10.1	8.5	10.1	

					65	1.51	1.74	2.201	13.2	20	13.2	11.0	13.2	
					10	1.23	0.669	0.921	13.2	20	5.1	4.6	5.1	
	2	27.2	1.53	1.45	30	1.41	1.251	1.71	13.2	20	9.5	8.6	9.5	11.2
					65	1.52	1.939	2.467	13.2	20	14.7	12.3	14.7	
					10	1.24	0.869	1.121	13.2	20	6.6	5.6	6.6	
	3	26.6	1.54	1.46	30	1.41	1.451	1.911	13.2	20	11.0	9.6	11.0	12.8
					65	1.54	2.139	2.667	13.2	20	16.2	13.3	16.2	
					10	1.25	0.443	0.588	13.2	20	3.4	2.9	3.4	
	1	35	1.44	1.37	30	1.36	0.615	0.861	13.2	20	4.7	4.3	4.7	4.8
					65	1.49	0.767	1.001	13.2	20	5.8	5.0	5.8	
					10	1.28	0.339	0.382	13.2	20	2.6	1.9	2.6	
TP4	2	33.1	1.46	1.39	30	1.4	0.854	1.15	13.2	20	6.5	5.8	6.5	6.2
					65	1.51	1.138	1.503	13.2	20	8.6	7.5	8.6	
					10	1.23	0.561	0.756	13.2	20	4.3	3.8	4.3	
	3	31.2	1.49	1.42	30	1.36	0.81	1.052	13.2	20	6.1	5.3	6.1	7.2
					65	1.47	1.083	1.41	13.2	20	8.2	7.1	8.2	
					10	1.28	0.74	1.004	13.2	20	5.6	5.0	5.6	
	1	32	1.47	1.40	30	1.34	0.89	1.218	13.2	20	6.7	6.1	6.7	7.6
					65	1.44	1.114	1.444	13.2	20	8.4	7.2	8.4	
					10	1.31	0.379	0.478	13.2	20	2.9	2.4	2.9	
TP5	2	31.7	1.48	1.41	30	1.41	0.958	1.209	13.2	20	7.3	6.0	7.3	7.8
					65	1.45	1.208	1.478	13.2	20	9.2	7.4	9.2	
					10	1.32	0.527	0.736	13.2	20	4.0	3.7	4.0	
	3	28.6	1.51	1.43	30	1.42	1.116	1.578	13.2	20	8.5	7.9	8.5	9
					65	1.5	1.45	2.015	13.2	20	11.0	10.1	11.0	
TP6	1	33.5	1.46	1.39	10	1.28	0.303	0.375	13.2	20	2.3	1.9	2.3	6.8
					30	1.34	0.727	1.026	13.2	20	5.5	5.1	5.5	

					65	1.46	1.134	1.641	13.2	20	8.6	8.2	8.6	
	2	31	1.5	1.43	10	1.29	0.525	0.701	13.2	20	4.0	3.5	4.0	8.4
					30	1.38	0.971	1.283	13.2	20	7.4	6.4	7.4	
					65	1.52	1.347	1.786	13.2	20	10.2	8.9	10.2	
	3	27.4	1.53	1.45	10	1.24	0.653	0.873	13.2	20	4.9	4.4	4.9	10
					30	1.41	1.214	1.557	13.2	20	9.2	7.8	9.2	
					65	1.53	1.52	1.985	13.2	20	11.5	9.9	11.5	
TP7	1	34.2	1.43	1.36	10	1.24	0.478	0.584	13.2	20	3.6	2.9	3.6	5.2
					30	1.33	0.728	0.899	13.2	20	5.5	4.5	5.5	
					65	1.43	0.978	1.307	13.2	20	7.4	6.5	7.4	
	2	31.6	1.47	1.40	10	1.25	0.589	0.861	13.2	20	4.5	4.3	4.5	7.2
					30	1.37	0.891	1.312	13.2	20	6.8	6.6	6.8	
					65	1.51	1.255	1.823	13.2	20	9.5	9.1	9.5	
	3	28.8	1.52	1.44	10	1.26	0.815	1.173	13.2	20	6.2	5.9	6.2	10.4
					30	1.37	1.174	1.562	13.2	20	8.9	7.8	8.9	
					65	1.5	1.569	2.08	13.2	20	11.9	10.4	11.9	
TP8	1	34.5	1.44	1.37	10	1.21	0.425	0.561	13.2	20	3.2	2.8	3.2	6.2
					30	1.33	0.768	1.101	13.2	20	5.8	5.5	5.8	
					65	1.47	1.104	1.482	13.2	20	8.4	7.4	8.4	
	2	30.8	1.45	1.38	10	1.25	0.499	0.612	13.2	20	3.8	3.1	3.8	6.6
					30	1.34	0.814	1.13	13.2	20	6.2	5.7	6.2	
					65	1.47	1.148	1.483	13.2	20	8.7	7.4	8.7	
	3	30.5	1.47	1.40	10	1.25	0.364	0.494	13.2	20	2.8	2.5	2.8	6.8
					30	1.35	0.814	1.161	13.2	20	6.2	5.8	6.2	
					65	1.49	1.085	1.469	13.2	20	8.2	7.3	8.2	
TP9	1	34.5	1.41	1.34	10	1.22	0.231	0.303	13.2	20	1.8	1.5	1.8	4.4
					30	1.33	0.572	0.821	13.2	20	4.3	4.1	4.3	

					65	1.43	0.872	1.209	13.2	20	6.6	6.0	6.6	
	2	35.4	1.44	1.37	10	1.21	0.279	0.372	13.2	20	2.1	1.9	2.1	4.8
					30	1.31	0.553	0.706	13.2	20	4.2	3.5	4.2	
					65	1.46	0.789	1.014	13.2	20	6.0	5.1	6.0	
	3	31.6	1.45	1.38	10	1.24	0.403	0.583	13.2	20	3.1	2.9	3.1	6
					30	1.35	0.73	1.05	13.2	20	5.5	5.3	5.5	
					65	1.49	1.006	1.401	13.2	20	7.6	7.0	7.6	
TP10	1	35.8	1.39	1.32	10	1.2	0.282	0.388	13.2	20	2.1	1.9	2.1	3.4
					30	1.31	0.465	0.567	13.2	20	3.5	2.8	3.5	
					65	1.4	0.581	0.734	13.2	20	4.4	3.7	4.4	
	2	33.6	1.45	1.38	10	1.23	0.335	0.461	13.2	20	2.5	2.3	2.5	5.6
					30	1.31	0.626	0.855	13.2	20	4.7	4.3	4.7	
					65	1.41	0.971	1.234	13.2	20	7.4	6.2	7.4	
	3	31.5	1.47	1.40	10	1.26	0.569	0.821	13.2	20	4.3	4.1	4.3	6.8
					30	1.43	0.951	1.411	13.2	20	7.2	7.1	7.2	
					65	1.52	1.439	1.967	13.2	20	10.9	9.8	10.9	

For the sake of illustration the following typical Load Versus Penetration relationship Curve and Dry Density Versus Soaked CBR Value graph are shown below to determine the load of the specimen at 2.54mm and 5.08mm; and to determine the CBR Value between the three points, i.e. at 10, 30 and 65 blows. The detail analysis of all samples is presented under Appendix N of this thesis.

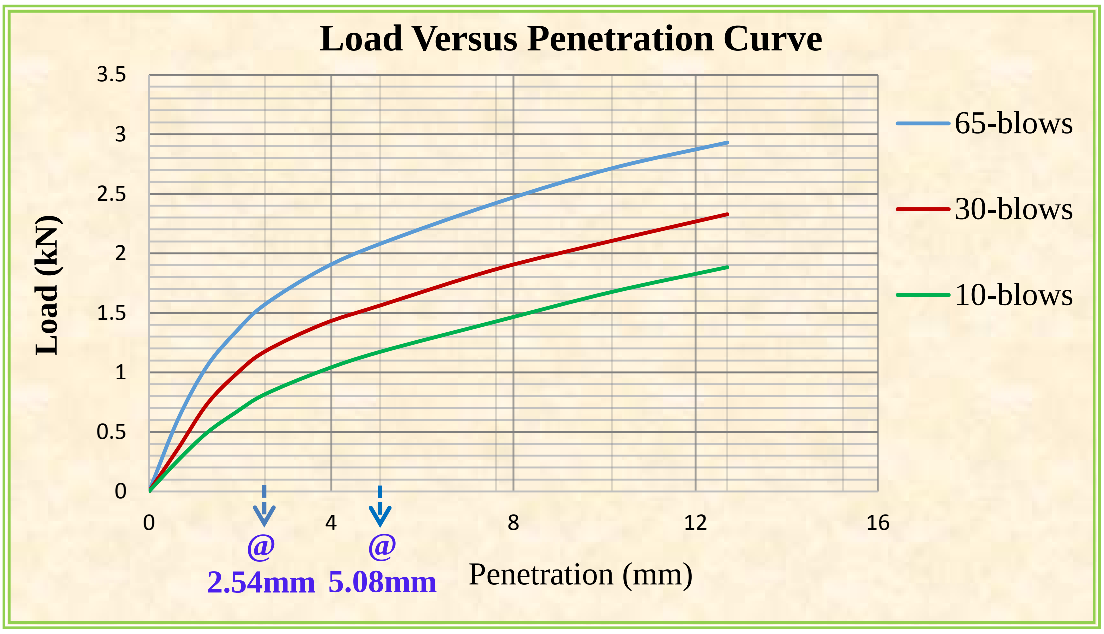


Figure 4.7: Typical Load versus Penetration Curve of Soil Sample at (TP7 @ 3m)

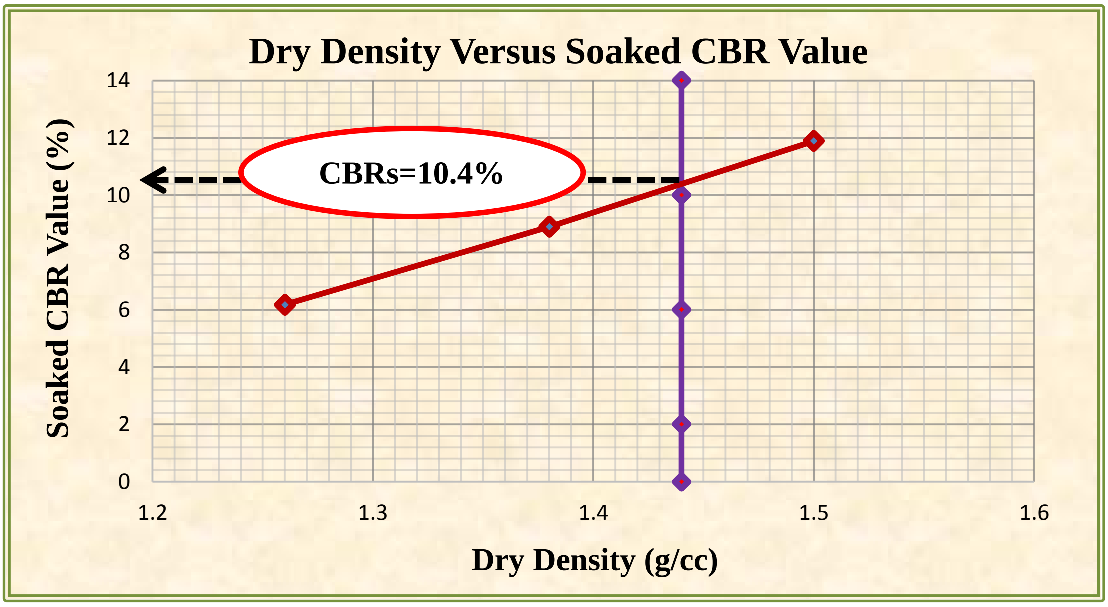


Figure 4.8: Typical Dry Density Vs CBR Value graph of Soil Sample at (TP7 @ 3m

4.1.7.1 CBR Swell Data after Four Days of Soaking

Table 4.5: Swell Data and Subgrade Material Volume Change after Four Days of Soaking

<table>
<tr><td colspan="9">CBR Swell Data from CBR Test</td></tr>
<tr><td colspan="4">Height of Spacer Disc = 50mm</td><td colspan="4">Height of perforated base plate =10mm</td><td rowspan="4">Subgrade material volume expansion</td></tr>
<tr><td colspan="4">Height of Mold =170.24mm</td><td colspan="3">Initial height of Specimen (mm)</td><td>110.24</td></tr>
<tr><td rowspan="2">Test Pits</td><td rowspan="2">Depth (m)</td><td rowspan="2">Number of blows</td><td rowspan="2">Initial DGR</td><td rowspan="2">Final DGR</td><td colspan="2">Amount of Swell</td><td>Av.Swell</td></tr>
<tr><td>(mm)</td><td>(%)</td><td>(%)</td></tr>
<tr><td rowspan="9">TP1</td><td rowspan="3">1</td><td>10</td><td>25+30</td><td>28+33</td><td>3.0</td><td>2.7</td><td rowspan="3">2.4</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>24+70</td><td>27+45</td><td>2.8</td><td>2.5</td></tr>
<tr><td>65</td><td>28+65</td><td>30+92</td><td>2.3</td><td>2.1</td></tr>
<tr><td rowspan="3">2</td><td>10</td><td>30+75</td><td>33+55</td><td>2.8</td><td>2.5</td><td rowspan="3">2.3</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>30+55</td><td>33+28</td><td>2.7</td><td>2.5</td></tr>
<tr><td>65</td><td>28+35</td><td>30+45</td><td>2.1</td><td>1.9</td></tr>
<tr><td rowspan="3">3</td><td>10</td><td>24+83</td><td>27+54</td><td>2.7</td><td>2.5</td><td rowspan="3">2.1</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>23+59.5</td><td>26+23</td><td>2.6</td><td>2.4</td></tr>
<tr><td>65</td><td>24+98</td><td>26+59</td><td>1.6</td><td>1.5</td></tr>
<tr><td rowspan="9">TP2</td><td rowspan="3">1</td><td>10</td><td>26+32</td><td>29+27.5</td><td>3.0</td><td>2.7</td><td rowspan="3">2.4</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>30+83.5</td><td>33+46</td><td>2.6</td><td>2.4</td></tr>
<tr><td>65</td><td>20+47.5</td><td>22+72.5</td><td>2.3</td><td>2.0</td></tr>
<tr><td rowspan="3">2</td><td>10</td><td>22+32</td><td>24+92</td><td>2.6</td><td>2.4</td><td rowspan="3">2.3</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>28+15</td><td>30+71</td><td>2.6</td><td>2.3</td></tr>
<tr><td>65</td><td>29+12</td><td>31+52.5</td><td>2.4</td><td>2.2</td></tr>
<tr><td rowspan="3">3</td><td>10</td><td>28+71</td><td>31+38</td><td>2.7</td><td>2.4</td><td rowspan="3">2.1</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>28+10</td><td>30+50</td><td>2.4</td><td>2.2</td></tr>
<tr><td>65</td><td>27+9</td><td>28+97</td><td>1.9</td><td>1.7</td></tr>
<tr><td rowspan="9">TP3</td><td rowspan="3">1</td><td>10</td><td>21+20</td><td>23+45</td><td>2.3</td><td>2.0</td><td rowspan="3">1.8</td><td rowspan="3">Low</td></tr>
<tr><td>30</td><td>26+58</td><td>28+62</td><td>2.0</td><td>1.9</td></tr>
<tr><td>65</td><td>28+40</td><td>30+10</td><td>1.7</td><td>1.5</td></tr>
<tr><td rowspan="3">2</td><td>10</td><td>25+84</td><td>28+10</td><td>2.3</td><td>2.1</td><td rowspan="3">1.7</td><td rowspan="3">Low</td></tr>
<tr><td>30</td><td>19+59</td><td>21+57</td><td>2.0</td><td>1.8</td></tr>
<tr><td>65</td><td>28+76</td><td>30+29</td><td>1.5</td><td>1.4</td></tr>
<tr><td rowspan="3">3</td><td>10</td><td>28+86</td><td>31+5</td><td>2.2</td><td>2.0</td><td rowspan="3">1.7</td><td rowspan="3">Low</td></tr>
<tr><td>30</td><td>27+7</td><td>29+2</td><td>2.0</td><td>1.8</td></tr>
<tr><td>65</td><td>28+98</td><td>30+40</td><td>1.4</td><td>1.3</td></tr>
<tr><td rowspan="9">TP4</td><td rowspan="3">1</td><td>10</td><td>25+99</td><td>30+27.5</td><td>4.3</td><td>3.9</td><td rowspan="3">3.0</td><td rowspan="3">High</td></tr>
<tr><td>30</td><td>30+89</td><td>33+52.5</td><td>2.7</td><td>2.5</td></tr>
<tr><td>65</td><td>31+63</td><td>34+39</td><td>2.8</td><td>2.5</td></tr>
<tr><td rowspan="3">2</td><td>10</td><td>24+51</td><td>27+80</td><td>3.3</td><td>3.0</td><td rowspan="3">2.5</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>27+11.5</td><td>30+25.5</td><td>3.1</td><td>2.8</td></tr>
<tr><td>65</td><td>22+51.5</td><td>24+35</td><td>1.8</td><td>1.7</td></tr>
<tr><td rowspan="3">3</td><td>10</td><td>27+21</td><td>30+37</td><td>3.2</td><td>2.9</td><td rowspan="3">2.4</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>24+23.5</td><td>27+8</td><td>2.8</td><td>2.6</td></tr>
<tr><td>65</td><td>28+87</td><td>30+87</td><td>2.0</td><td>1.8</td></tr>
<tr><td rowspan="7">TP5</td><td rowspan="3">1</td><td>10</td><td>23+84</td><td>26+72</td><td>2.9</td><td>2.6</td><td rowspan="3">2.3</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>20+53.5</td><td>23+6</td><td>2.5</td><td>2.3</td></tr>
<tr><td>65</td><td>27+18</td><td>29+47</td><td>2.3</td><td>2.1</td></tr>
<tr><td rowspan="3">2</td><td>10</td><td>31+40</td><td>34+18</td><td>2.8</td><td>2.5</td><td rowspan="3">2.2</td><td rowspan="3">Medium</td></tr>
<tr><td>30</td><td>30+79</td><td>33+25</td><td>2.5</td><td>2.2</td></tr>
<tr><td>65</td><td>25+88</td><td>27+91</td><td>2.0</td><td>1.8</td></tr>
<tr><td>3</td><td>10</td><td>21+45.5</td><td>24+18</td><td>2.7</td><td>2.5</td><td>2.1</td><td>Medium</td></tr>
</table>

		30	30+73.5	33+7	2.3	2.1		
		65	26+34	28+19	1.9	1.7		
TP6	1	10	24+58	27+29	2.7	2.5	2.3	Medium
		30	27+40	29+93	2.5	2.3		
		65	29+24	31+55	2.3	2.1		
	2	10	22+50	25+22	2.7	2.5	2.2	Medium
		30	26+11.5	28+65	2.5	2.3		
		65	27+27	29+28	2.0	1.8		
	3	10	25+74	28+5	2.3	2.1	1.8	Low
		30	26+97	29+2	2.1	1.9		
		65	20+44	22+18	1.7	1.6		
TP7	1	10	24+34	27+97	3.6	3.3	2.8	Medium
		30	21+76	24+92	3.2	2.9		
		65	27+36	29+98	2.6	2.4		
	2	10	27+18	30+25	3.1	2.8	2.4	Medium
		30	24+25.5	27+8	2.8	2.6		
		65	28+77	30+83	2.1	1.9		
	3	10	21+23	23+47	2.2	2.0	1.8	Low
		30	26+60	28+66	2.1	1.9		
		65	28+42	30+17	1.8	1.6		
TP8	1	10	25+54	28+84	3.3	3.0	2.5	Medium
		30	27+14	30+18.5	3.0	2.8		
		65	22+42.5	24+25	1.8	1.7		
	2	10	26+42	29+37	3.0	2.7	2.3	Medium
		30	30+85	33+36	2.5	2.3		
		65	20+48	22+71	2.2	2.0		
	3	10	24+48	27+26	2.8	2.5	2.3	Medium
		30	27+43	29+83	2.4	2.2		
		65	29+27	31+57	2.3	2.1		
TP9	1	10	26+1	29+70.5	3.7	3.4	3.0	High
		30	30+93	33+97.5	3.0	2.8		
		65	31+66	34+69	3.0	2.7		
	2	10	25+97	29+69.5	3.7	3.4	2.8	Medium
		30	30+90	33+72.5	2.8	2.6		
		65	31+64	34+30	2.7	2.4		
	3	10	24+44	27+57	3.1	2.8	2.5	Medium
		30	21+66	24+32	2.7	2.4		
		65	27+22	29+64	2.4	2.2		
TP10	1	10	27+20	30+62	3.4	3.1	3.1	High
		30	28+33	32+25.5	3.9	3.6		
		65	31+47	34+26	2.8	2.5		
	2	10	23+34	26+64	3.3	3.0	2.6	Medium
		30	20+76	23+52	2.8	2.5		
		65	26+36	28+84	2.5	2.2		
	3	10	25+58	28+33	2.8	2.5	2.3	Medium
		30	27+44	29+96	2.5	2.3		
		65	29+24	31+58	2.3	2.1		

Table 4.6: Summary of all Laboratory Test Result

Test Pits	Depth (m)	NMC	GS	Grain Size Analysis (Percent Passing)			Atterberg's Limits Result			Soil Classification System		Modified Proctor Compaction Test Result		CBR @ 95% MDD
				4.75 (mm)	2 (mm)	0.075 (mm)	LL (%)	PL (%)	PI (%)	AASHTO	USCS	OMC (%)	MDD (g/cc)	
TP1	1	41.6	2.67	100	99.2	87.5	60.8	32.5	28.3	A-7-5(29)	MH	32.7	1.46	7.0
	2	39.3	2.66	100	99.7	84.2	56.4	30.2	26.2	A-7-5(25)	MH	32.5	1.45	7.4
	3	38.8	2.65	100	99.2	82.6	53.6	29.8	23.8	A-7-6(22)	MH	28.8	1.5	8.0
TP2	1	40.1	2.68	100	98.8	89.2	70.8	36.4	34.4	A-7-5(37)	MH	32.3	1.48	6.4
	2	39.4	2.67	100	98.8	85.8	67.6	38.4	29.2	A-7-5(31)	MH	31.5	1.49	7.6
	3	37.1	2.67	99.7	98.4	76.5	64.9	36.4	28.5	A-7-5(25)	MH	28.2	1.51	8.2
TP3	1	38.5	2.68	99.7	98.7	78.4	49.6	29.9	19.7	A-7-6(17)	ML	27.5	1.51	10.5
	2	37.4	2.66	99.4	97.4	76.4	48.4	29.8	18.6	A-7-6(15)	ML	27.2	1.53	11.2
	3	36.7	2.66	99.2	97.3	74.8	46.8	27.9	18.9	A-7-6(15)	ML	26.2	1.54	12.8
TP4	1	40.3	2.69	100	99.5	82.8	71.2	44.6	26.6	A-7-5(28)	MH	35.0	1.44	4.8
	2	40.2	2.67	100	99.4	81.1	73.5	44.3	29.2	A-7-5(30)	MH	33.1	1.46	6.2
	3	39.8	2.67	100	99.3	78.4	69.4	39.4	30	A-7-5(28)	MH	31.2	1.49	7.2
TP5	1	41.4	2.68	99.8	98.0	82.8	69.6	38.8	30.8	A-7-5(31)	MH	32	1.46	7.6

	2	40.5	2.67	99.7	99.0	81.2	66.6	37.3	29.3	A-7-5(28)	MH	29.7	1.49	7.8
	3	39.5	2.66	99.5	98.2	80.7	60.2	32.6	27.6	A-7-5(25)	ML	27.6	1.52	9.0
TP6	1	40.5	2.67	99.7	99.2	86.4	60.8	33.4	27.4	A-7-5(28)	MH	33.5	1.46	6.8
	2	40.1	2.66	99.7	99.0	84.8	50	29.4	20.6	A-7-6(20)	MH	27.6	1.5	8.4
	3	38.4	2.65	99.6	98.8	80.1	46	28.2	17.8	A-7-6(15)	ML	26.4	1.53	10.0
TP7	1	42.4	2.7	99.9	99.6	81.7	70	42.1	27.9	A-7-5(28)	MH	34.2	1.39	5.2
	2	41.9	2.68	99.6	98.5	81.4	68	37.3	30.7	A-7-5(30)	MH	29.8	1.47	7.2
	3	40.3	2.66	99.5	98.2	78.3	48.5	28.8	19.7	A-7-6(17)	ML	28.7	1.51	10.4
TP8	1	40.2	2.68	100	99.6	84.6	64.4	34.6	29.8	A-7-5(30)	MH	34.5	1.42	6.2
	2	38.4	2.68	100	99.5	81.9	60.8	32.4	28.4	A-7-5(27)	MH	30.8	1.43	6.6
	3	37.4	2.67	100	99.5	79.7	57.5	31.4	26.1	A-7-5(23)	MH	30.5	1.46	6.8
TP9	1	42.5	2.7	100	99.1	90.7	74	42.5	31.5	A-7-5(37)	MH	34.5	1.38	4.4
	2	41.7	2.69	100	99.3	84.9	73	41.6	31.4	A-7-5(33)	MH	35.4	1.43	4.8
	3	40.8	2.67	100	98.6	80.4	66.6	35.4	31.2	A-7-5(20)	MH	31.6	1.45	6.0
TP10	1	42.8	2.72	100	100.0	88.2	76	40.4	35.6	A-7-5(39)	MH	35.6	1.37	3.4
	2	42.1	2.7	100	99.6	86.9	74.8	41.2	33.6	A-7-5(36)	MH	33.6	1.41	5.6
	3	41.4	2.67	100	99.9	86.1	73	41.5	31.5	A-7-5(34)	MH	31.5	1.47	6.8

4.1.8 Discussion on the Laboratory Test Result

Depending on the Natural moisture content laboratory test result, the Natural water content of the soil in the study area varied from 36.7% to 42.8% which indicates that the soil in the study area is fine-grained soil.

A natural moisture content close to the plastic limit confirms a firm to stiff clay whereas a natural moisture content approaching liquid limit indicates a soft clay. Therefore, based on the comparison between plastic limit and natural moisture content result obtained from the laboratory, the soil in the study area falls in the range of firm to stiff clay.

According to the test results of the specific gravity test, the Specific gravity of the soil in the study area is varied from 2.65 to 2.72, which indicate the soil in the study area is in the range of inorganic soil (silt to silty clay).

In the case of Grain Size Analysis result, for all test pits the percentage passing sieve no. 200 or percent of finer is more than 35% and is varied in the range of 74.8% to 90.7%. This result indicates that the soil in the study area is mainly fine grained and classified under silt and clay.

Based on the Grain Size Analysis and Atterberg's Limits test result, according to USCS and AASHTO Classification System, the soil in the study area is categorized as MH and ML (high plastic and low plastic) silt soil and A-7-5 and A-7-6 (clayey soil) respectively.

The California Bearing Ratio (CBR) Value of the Soil in the study area is varied from 3.4% to 12.8%. According to ERA Manual-2002, this range of typical CBR value indicate the soil in the study area is to be classified as fine grained inorganic soil, and the obtained result within the range of (MH) and (ML) which is high plastic and low plastic Silt soil respectively.

As recommended on the Pavement Design Manual Volume I flexible Pavements and Gravel Roads of ERA Manual-2002, depending on the CBR Value of the Soil of the study area which ranges from 3.4% to 12.8%, and the general rating for a pavement subgrade support value as sub grade material is considered as poor to fair.

A group index value (GI) of the soil in the study area is varied from 15 to 39 which indicates the performance as a subgrade material is from good to poor.

In pavement Design, Ethiopian Roads Authority Site Investigation Manual 2002 recommends that the road section must be defined in accordance with subgrade strength classes depending on the range of CBR value. Therefore, depending on the CBR value obtained, the subgrade strength class of the soil in the study area classified as S2 (CBR range 3-4 %), S3 (CBR range 5-7%) and S4 (CBR range 8-14%), but dominantly classified as S3 subgrade strength class.

After four days of soaking the average swelling condition of the soil in the study area during CBR test is varied from 1.7% to 3.1% which indicate that the soil in the study area is in the range of low to high volume expansion. If the subgrade material is likely to be subjected to an increase in moisture content, either from rainfall, groundwater or ingress through the surfacing, it is probable that its strength hence CBR will decrease due to the subgrade volume change. Therefore, for design purposes maintaining proper drainage facility is recommended depending on this swelling condition. Hence, the subgrade should be designed considering as there is low to high subgrade volume change or movement as the moisture content increases as a result of the worst condition from the site.

Generally, based on the whole laboratory test result of the soil index properties, the relation between CBR value and the index properties can be described as, as natural moisture content, specific gravity, grain size analysis (percent of silt-clay), atterberg limits parameters (LL, PL and PI) and from compaction characteristics as optimum moisture content increases the California bearing ratio value is decreases. However, as percent of gravel and sand, and maximum dry density of soil increases the California bearing ratio value is increases. This situation is indicates that all parameters have their own contributions on the California bearing ration value, however, the degree to which they affect CBR value is not the same.

4.2 Correlation and Regression Analysis Result

4.2.1 Sample size result

Sample size is an important feature of any study or investigation in which the aim is to make inferences about the population from a sample.

$$N = \frac{z^2 * SD^2}{MRE^2} \quad [29] \qquad (4.1)$$

Z=1.96 for 95% confidence interval

SD = Standard deviation of the mean = 0.14

MRE = 0.05 for 95% confidence interval,

$$N = \frac{(1.96)^2 * (0.14)^2}{(0.05)^2} \approx 30$$

4.2.2 Discussion on sample size result

From the above calculation, the sample size result is 30. This result was depending on the predicted standard deviation taken from previous literature, margin of error and Z value. According to [52] if ten or above tests are made, the variation of their sample average from population would have a standard deviation of 10-20%. Based on the above stated reason the predicted standard deviation of the mean was 14% (0.14). The margin of error and level of significance are depend on the level of confidence interval. The 95% percent of level of confidence interval gives 5% of margin error from the population mean and Z-value 1.96 which represent the probability that a sample will fall within a certain distribution.

4.2.3 Scatter Plots Result

Prior to carrying out the regression analysis a scatter diagram is generated by applying the Excel Spreadsheet, in order to study the relationships developed between the dependent variable and the predictors variables so as to determine the model that best suits the test results.

As discussed so far in this study, the California Bearing Ratio is taken as the dependent variable whereas PP200, the percent passing No.200 (0.075mm) sieve size, LL, PL, PI, OMC and MDD are considered as independent variables. The scatter plots of the dependent variable CBR with each independent variable, CBR with PP200, LL, PL, PI, OMC and MDD for the 30 samples were done by using Ms. Excel, and the plots are presented in the figures below.

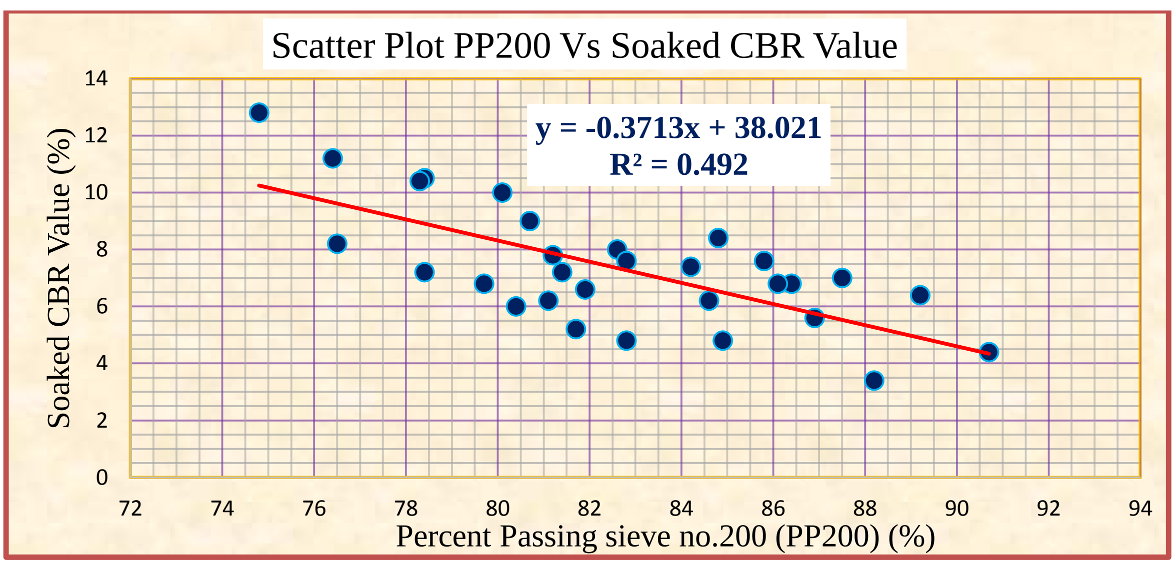


Figure 4.9: Scatter diagram of Soaked CBR Value versus Percent Passing Sieve no.200

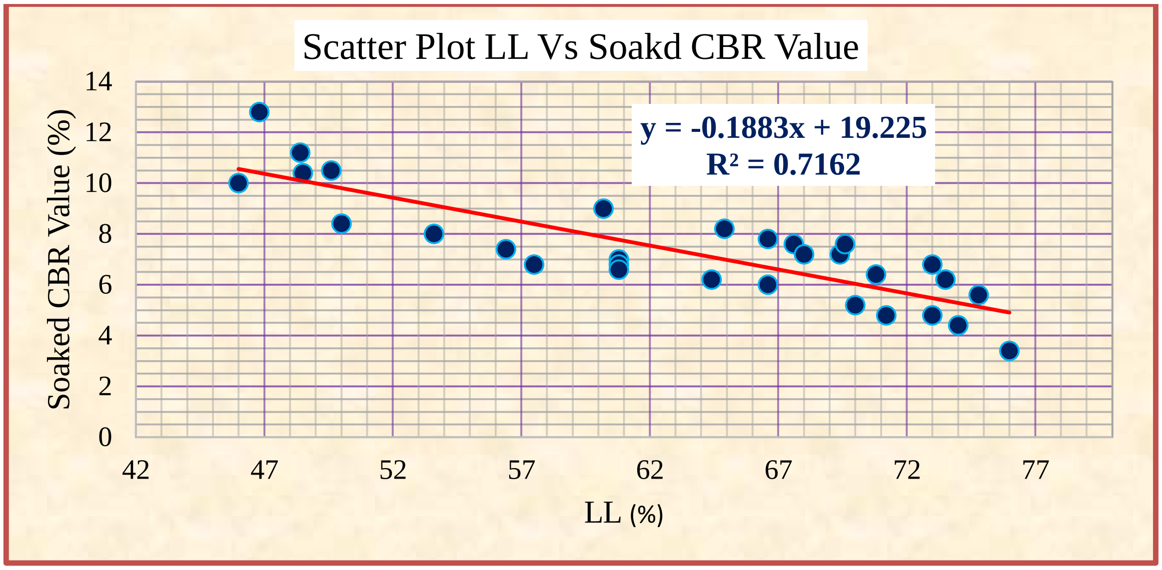


Figure 4.10: Scatter diagram of Soaked CBR Value versus LL

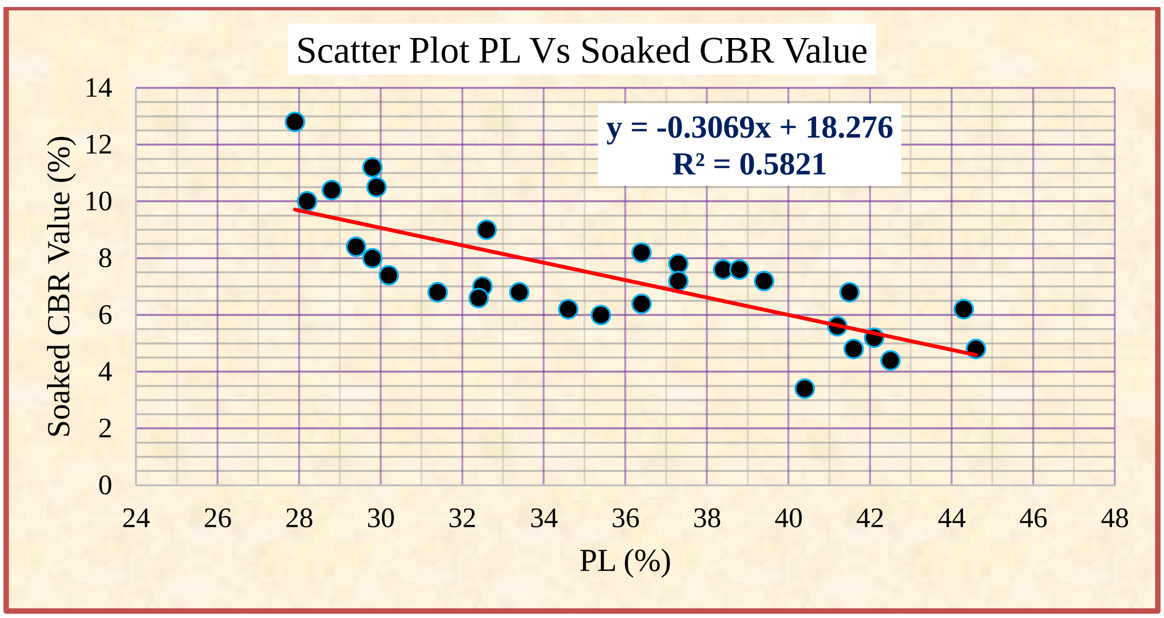


Figure 4.11: Scatter diagram of Soaked CBR Value versus PL

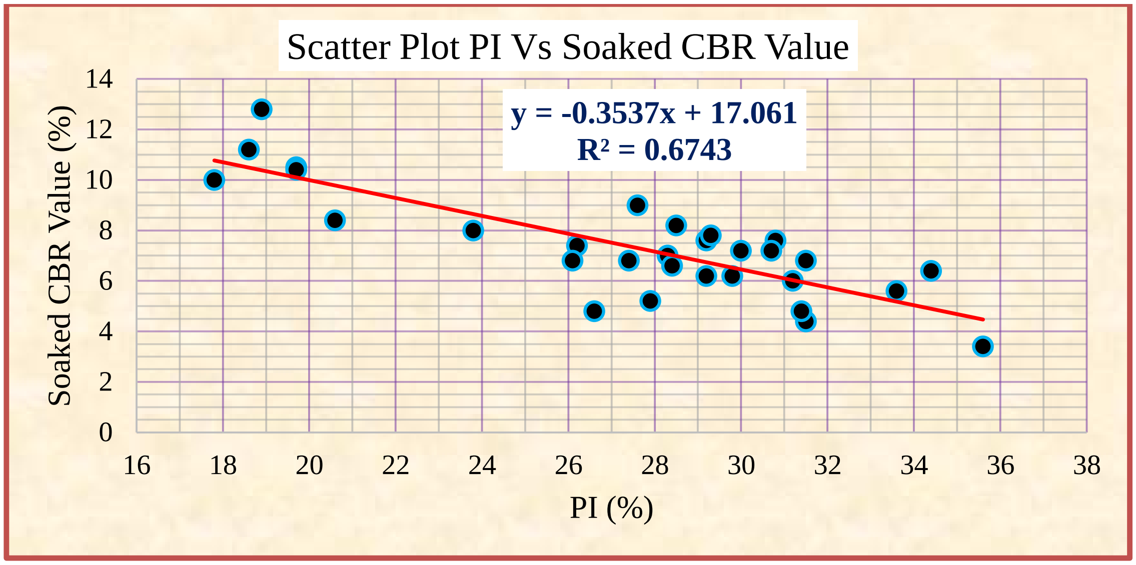


Figure 4.12: Scatter diagram of Soaked CBR Value versus PI

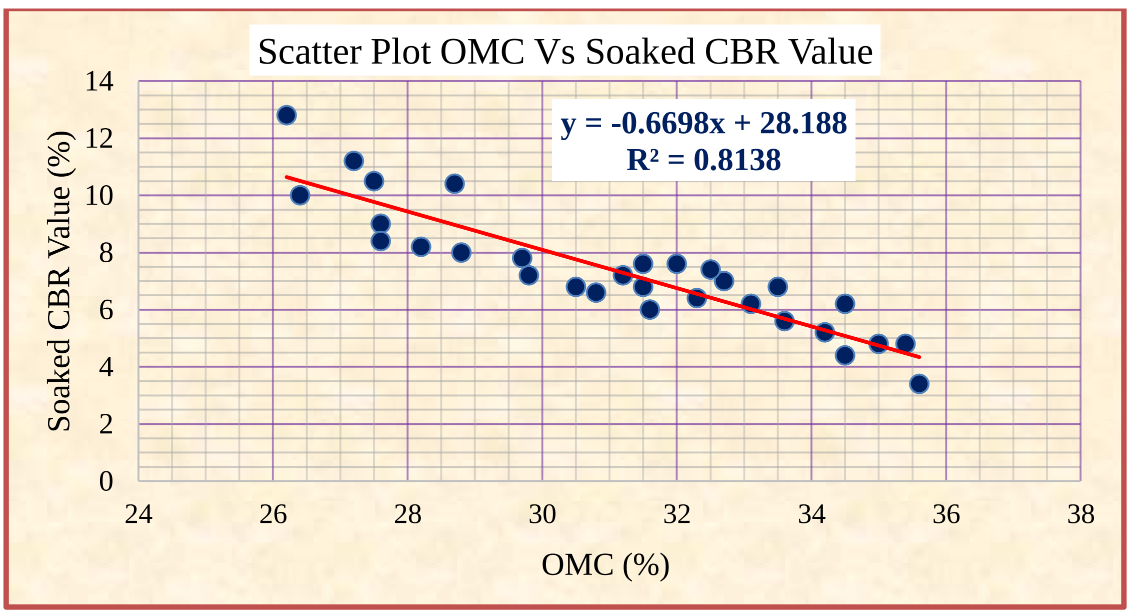


Figure 4.13: Scatter diagram of Soaked CBR Value versus OMC

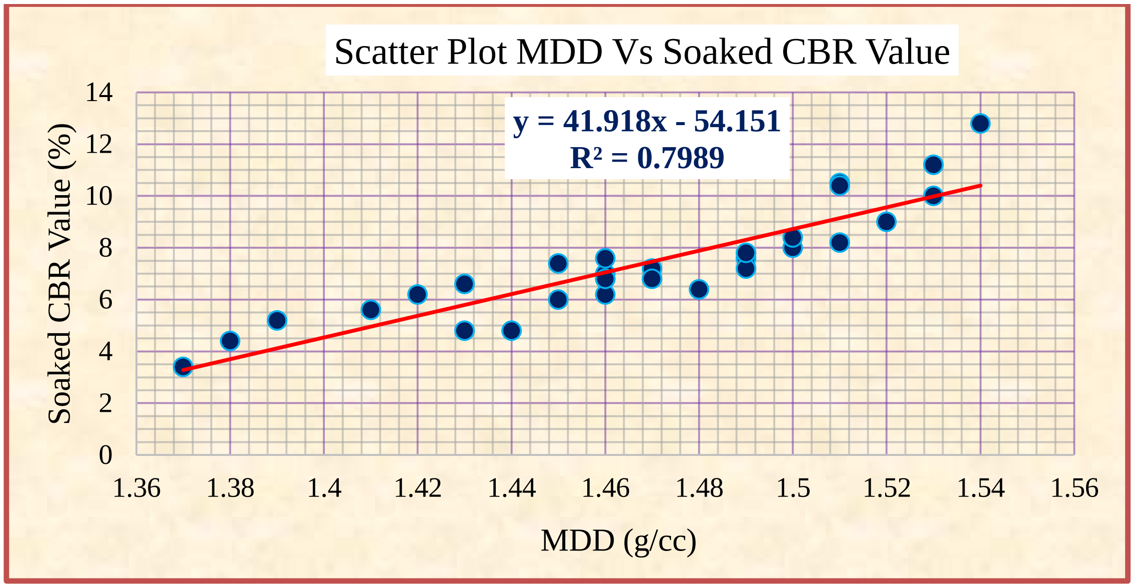


Figure 4.14: Scatter diagram of Soaked CBR Value versus MDD

4.2.3.1 Discussion on the Scatter Plots result

From the above scatter plots it is observed that for independent variables PP200, LL, PL, PI and OMC, the points are scattered randomly downward trend around a straight line. This shows that these parameters have a negative relationship with a dependent variable (CBR). However, for MDD the points are scattered randomly increasing trend around a straight line. This shows that MDD has a positive relationship with the CBR.

4.2.4 Descriptive statistics

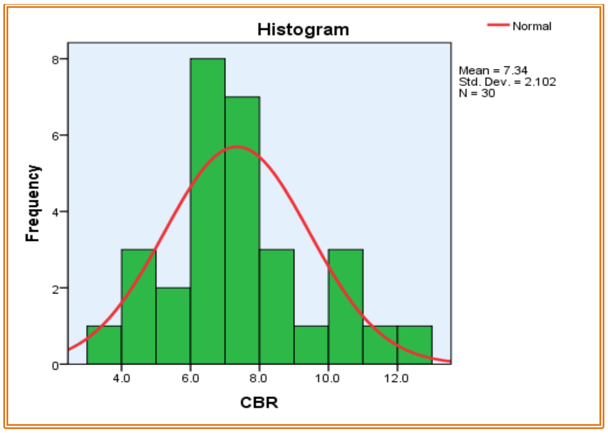
Table 4.7: Statistical Information of Dependent and Independent Variables

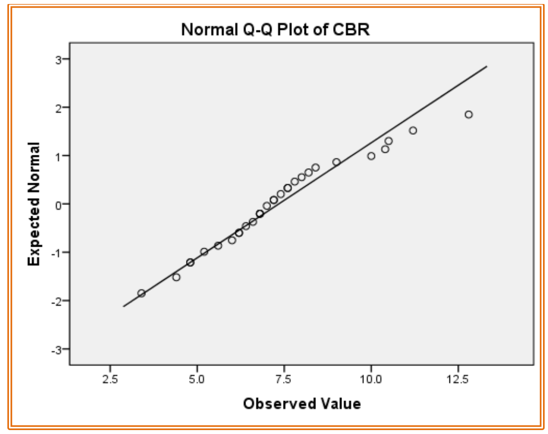
Descriptive Statistics								
Variables	Unit	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
CBR	%	30	9.4	3.4	12.8	7.343	2.1015	4.416
PP200	%	30	15.9	74.8	90.7	82.617	3.9699	15.760
LL	%	30	30.0	46.0	76.0	63.093	9.4439	89.187
PL	%	30	16.7	27.9	44.6	35.583	5.2284	27.337
PI	%	30	17.8	17.8	35.6	27.477	4.8790	23.805
OMC	%	30	9.4	26.2	35.6	31.123	2.8306	8.012
MDD	g/cc	30	.17	1.37	1.54	1.4670	.04481	.002
Valid N (listwise)		30						

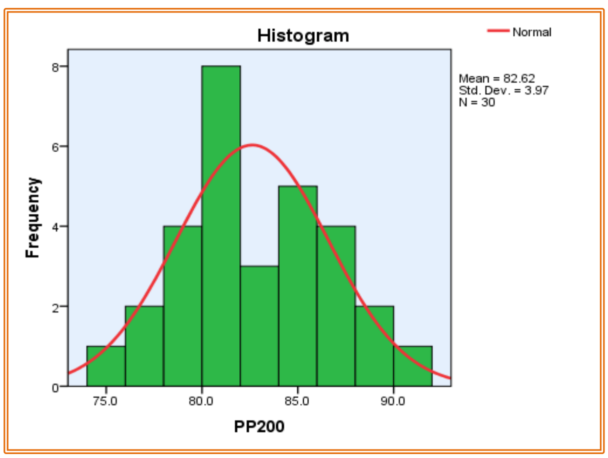
4.2.5 Normality Test Result

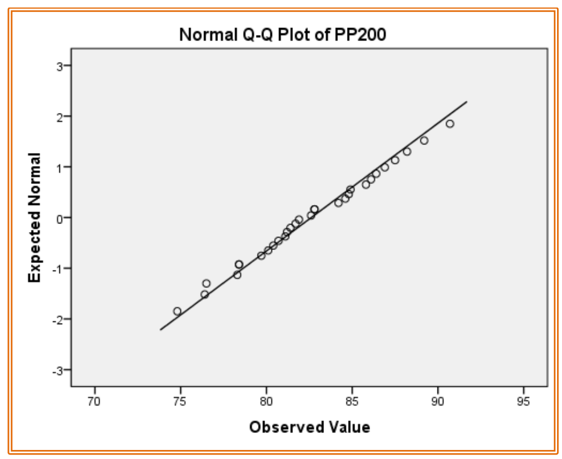
4.2.5.1 Graphical methods of Normality test result

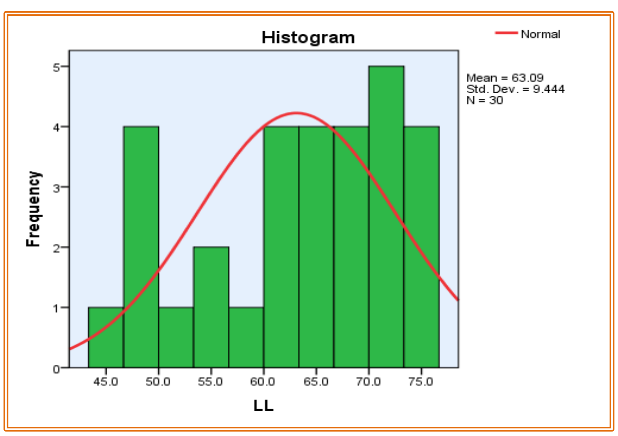
The result of normality test using graphical methods using both histogram and normal Q-Q plot are shown as figures below.

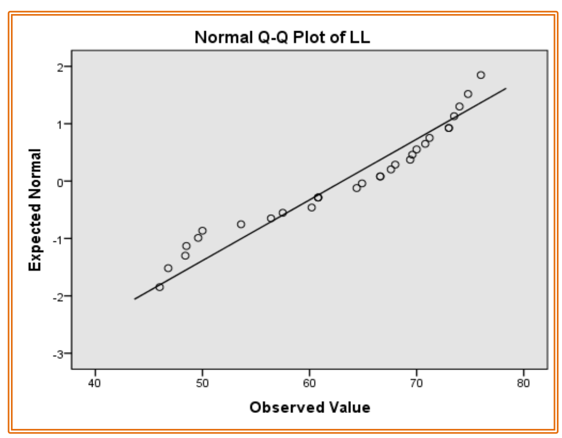












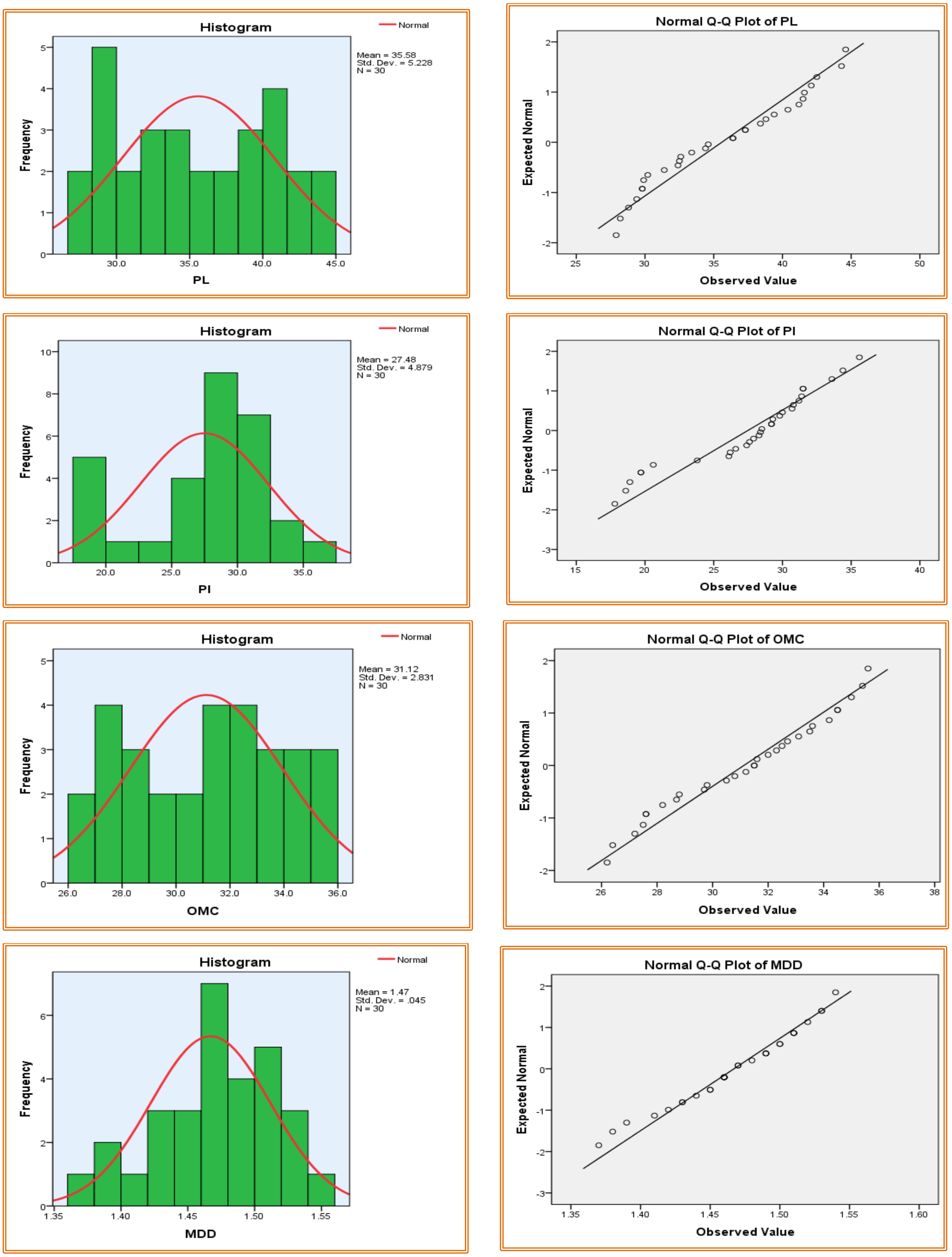


Figure 4.15: Graphical methods of normality test (both histogram and normal Q-Q plot)

4.2.5.2 Statistical (Analytical) methods of Normality test result

The result of normality test using analytical methods using different methods are shown as tables below.

Table 4.8: Normality Test result of Kolmogorov-Smirnov and Shapiro-Wilk Test

Tests of Normality						
Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CBR	.118	30	.200*	.964	30	.383
PP200	.082	30	.200*	.988	30	.973
LL	.145	30	.109	.915	30	.067
PL	.116	30	.200*	.938	30	.079
PI	.160	30	.057	.915	30	.063
OMC	.094	30	.200*	.954	30	.219
MDD	.105	30	.200*	.966	30	.445
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Table 4.9: Normality Test result according to Skewness and Kurtosis Coefficients

Variables	N	Skewness Value	SE of Skewness	Converted Z skewness	Kurtosis Value	SE of Kurtosis	Converted Z kurtosis	Critical Value of Z for 95% confidence interval	Results
CBR	30	.650	.427	1.52	.562	.833	0.67	-1.96 to +1.96	Normal
PP200	30	.059	.427	0.14	-.550	.833	-0.66	-1.96 to +1.96	Normal
LL	30	-.501	.427	-1.17	-1.054	.833	-1.27	-1.96 to +1.96	Normal
PL	30	.138	.427	0.32	-1.311	.833	-1.57	-1.96 to +1.96	Normal
PI	30	-.668	.427	-1.56	-.383	.833	-0.46	-1.96 to +1.96	Normal
OMC	30	-.162	.427	-0.38	-1.120	.833	-1.34	-1.96 to +1.96	Normal
MDD	30	-.436	.427	-1.02	-.369	.833	-0.44	-1.96 to +1.96	Normal

In the table above the skewness value, Standard error (SE) of skewness, kurtosis value and Standard error (SE) of kurtosis are taken from SPSS output attached at appendix A of this thesis

4.2.5.3 Discussion on Normality Test Result

Depending on both the graphical and statistical (analytical) normality test result, the normality test result fulfill the basic assumption of normality test. According to the graphical methods of normality test result, the data is approximately normally distributed through the visual examination from the histogram and normal Q-Q plot. The value of converted Z skewness and kurtosis is falls in the stated critical ranges,-1.96 to +1.96, which implies that the data satisfies the normality test. The Kolmogrov-Smirnovs and Shapiro-Wilk test shows the level of significance (α) greater than 0.05, which indicates the samples data are not significantly different than a normal population hence accept the null hypothesis. Generally, based on the tested normality test, the collected samples data are not significantly different from a normal population, which means the data distribution is reasonably close to normality. Hence the assumption in statistical analysis for normally distributed data fairly satisfied, the assumption of null hypothesis is accepted. The detail normality test out-put obtained for skewness and kurtosis coefficient is presented under appendix A of this thesis.

4.2.6 Correlation Matrix of Result Data

Based on the correlation matrix analysis, it is possible to explore the relationship strength and direction of all variables through pairwise associations between each variable. Depending on the correlation matrix the following correlation coefficients and level of significance was determined then the statistical hypothesis test is stated based on level of significance.

Ho: = there is a statistically relationship between dependent and independent variable

H_1: = there is no significant relationship between dependent and independent variable

If there is a statistically significant relationship between dependent and independent variable, the value of level of significance (α) value is less than 0.05 if not $\alpha > 0.05$ which indicates there is no significant relationship between dependent and independent variable .Here under, the Pearson correlation coefficient matrix obtained from the SPSS software is shown in table below.

Table 4.10: Correlation Matrix of Pearson correlation coefficient

Correlations								
		CBR	**PP200**	**LL**	**PL**	**PI**	**OMC**	**MDD**
CBR	Pearson Correlation	1	-.701**	-.846**	-.758**	-.821**	-.902**	.894**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
	N	30	30	30	30	30	30	30
PP200	Pearson Correlation	-.701**	1	.557**	.426*	.626**	.691**	-.647**
	Sig. (2-tailed)	.000		.001	.019	.000	.000	.000
	N	30	30	30	30	30	30	30
LL	Pearson Correlation	-.846**	.557**	1	.936**	.930**	.795**	-.709**
	Sig. (2-tailed)	.000	.001		.000	.000	.000	.000
	N	30	30	30	30	30	30	30
PL	Pearson Correlation	-.758**	.426*	.936**	1	.742**	.740**	-.635**
	Sig. (2-tailed)	.000	.019	.000		.000	.000	.000
	N	30	30	30	30	30	30	30
PI	Pearson Correlation	-.821**	.626**	.930**	.742**	1	.745**	-.689**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
	N	30	30	30	30	30	30	30
OMC	Pearson Correlation	-.902**	.691**	.795**	.740**	.745**	1	-.889**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
	N	30	30	30	30	30	30	30
MDD	Pearson Correlation	.894**	-.647**	-.709**	-.635**	-.689**	-.889**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	30	30	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4.2.6.1 Discussion of the correlation matrix result

To determine the correlation matrix, Pearson correlation coefficient is used. As observed on table above, to know the association of CBR value with the considered index properties of soil, correlation coefficient (R) and level of significance between the CBR value and PP200,LL,PL,PI,OMC and MDD were determined. Based on the above correlation matrix result, it is observed that the level of significance (*p*) value is less 0.05 and the Pearson correlation coefficient value (R) is relatively close to -1 and 1. These shows, the data accept the null hypothesis and conclude that there is a statistically significant relationship between dependent variable, (CBR) with the independent variables (PP200, LL, PL, PI, OMC and MDD). That is 95%, the relationship between dependent and the independent variables probably true. From the correlation matrix, it is noticed that there are perfect correlations between variables and themselves which is indicated by the diagonal value is unit. The matrix is symmetrical on either side of the diagonal, meaning all correlations are given twice.

More further to the above correlation analysis based on the Pearson correlation coefficient, a number of alternative linear regression analyses was carried out to develop model that best fits the obtained test result, and summarized under correlation and regression analysis result.

4.2.7 Multicollinearity (interdependency) test result

The following table shows the result of collinearity test between the independent variables.

Table 4.11: Multicollinearity test result

Coefficients[a]				
Model	Independent Variables	Collinearity Statistics		
		Tolerance	VIF	Remarks
1	PP200	0.402	2.485	Satisfied
	LL	0.086	12.086	Not satisfied
	PL	0.057	17.493	Not satisfied
	PI	0.065	15.344	Not satisfied
	OMC	0.136	7.337	Satisfied
	MDD	0.203	4.914	Satisfied
a. Dependent Variable: CBR				

4.2.7.1 Discussion on Multicollinearity test result

From table above, the variance inflation factor (VIF) values of the independent variables such as LL, PL and PI is greater than 10 and the tolerance statistics is less than 0.1 which indicates that there is a multicollinearity problem between these variables. Hence, these variables cannot be participated in the regression model at the same time with one another. However, the variance inflation factor (VIF) values and tolerance statistics of the independent variables like PP200, OMC and MDD is less than 10 and greater than 0.1 respectively. Therefore, we can safely conclude that there is no collinearity within these predictors.

In addition, from a correlation matrix, the pairwise Pearson correlation coefficient among the predictor variables like LL, PL and PI is greater than 0.9, ($R > 0.9$) which indicates that there is a multicollinearity problem between each variable. That is one of them may serve as a proxy or representative for the others in the regression model, or only one of them can be used, because their effect on the regression model is relatively considered to be the same. However, the pairwise Pearson correlation coefficient of the pair predictor variables such as pp200, OMC and MDD is less than 0.9, ($R < 0.9$) which indicates there is no interdependency between the predictors. That is each predictor can be independently participated in the model.

4.2.8 Correlation and Regression Analysis Output from SPSS Software

4.2.8.1 Single Linear Regression Analysis

Based on the resulting regression analysis for correlating CBR with PP200.LL, PL, PI, OMC and MDD, using a single linear regression the result obtained is presented below.

Model 1: Single Linear Regression Analysis between CBR and PP200

The resulting regression analysis after correlating CBR with Percent Passing No.200 sieve (PP200) is expressed by the following single linear equation with its corresponding correlation coefficients:

CBR = 38.021- 0.37PP200, with R^2 =0.492, R^2 (adj.) = 0.474, N=30 (4.2)

Model 2: Single Linear Regression Analysis between CBR and LL

The resulting regression analysis after correlating CBR with Liquid Limit (LL) is expressed by the following single linear equation with its corresponding correlation coefficients:

CBR = 19.225 – 0.188LL, with R^2 = 0.716, R^2 (adj.) = 0.706, N=30 (4.3)

Model 3: Single Linear Regression Analysis between CBR and PL

The resulting regression analysis after correlating CBR with Plastic Limit (PL) is expressed by the following single linear equation with its corresponding correlation coefficient:

CBR = 18.186 – 0.305PL, with R^2 = 0.575, R^2 (adj.) = 0.56, N=30 (4.4)

Model 4: Single Linear Regression Analysis between CBR and PI

The resulting regression analysis after correlating CBR with Plastic Index (PI) is expressed by the following single linear equation with its corresponding correlation coefficient:

CBR = 17.061 – 0.354PI, with R^2 = 0.674, R^2 (adj.) = 0.663, N=30 (4.5)

Model 5: Single Linear Regression Analysis between CBR and OMC

The resulting regression analysis after correlating CBR with Optimum Moisture Content (OMC) is expressed by the following single linear equation with its corresponding correlation coefficient:

CBR = 28.188 – 0.67OMC, with R^2 = 0.814, R^2 (adj.) = 0.807, N=30 (4.6)

Model 6: Single Linear Regression Analysis between CBR and MDD

The resulting regression analysis after correlating CBR with Maximum Dry Density (MDD) is expressed by the following single linear equation with its corresponding correlation coefficient:

CBR = -54.151 + 41.918MDD, with R^2 = 0.799, R^2 (adj.) = 0.792, N=30 (4.7)

4.2.8.2 Multiple Linear Regression Analysis

In this Multiple Linear regression analysis to predict a CBR value, a best fit equation have to be chosen after going through a number of alternatives combinations of predictors. To have an alternative approach to decide the best fit equation, different alternative combinations between and among different predictors were performed. Depending on coefficient of determination and standard error the following developed correlation models are selected as alternative to decide the best fit model.

1**. Model A:** Multiple Linear Regression Analysis between CBR with LL and MDD

CBR = -27.303 - 0.095LL + 27.707MDD, with R^2 = 0.89, R^2 (adj.) = 0.882, N=30 (4.8)

2**. Model B**: Multiple Linear Regression Analysis between CBR with LL, OMC and MDD

CBR = -12.124 - 0.077LL – 0.178OMC + 20.37MDD,

With R^2 = 0.899, R^2 (adj.) = 0.887, N=30 (4.9)

3. **Model C**: Multiple linear regression analysis between CBR with PP200, PI, OMC and MDD

CBR = -6.63 – 0.033PP200 - 0.128PI – 0.216OMC + 18.34MDD,

With R^2=0.892, R^2 (adj.) =0.884, N=30 (4.10)

4**. Model D**: Multiple linear regression analysis between CBR with PL, OMC, MDD and PP200

CBR = -7.251 – 0.102PL – 0.157OMC + 20.604MDD - 0.086PP200

With R^2 = 0.885, R^2 (adj.) = 0.86, N=30 (4.11)

4.2.8.3 Summary of the Developed Models

4.2.8.3.1 Summary of Models Developed from Single Linear Regression Analysis

The following table summarizes the models developed from Single Linear Regression Analysis based on the statistical parameters taken from model summary and ANOVA result.

Table 4.12: Summary of Models Developed from Single Linear Regression Analysis

Model Code	Single Regression Equations Developed Models	Statistical Parameters				
		R	R^2	R^2 adj.	Std.error	*P*-value
1	CBR=38.021- 0.371PP200	0.701	0.492	0.474	1.5243	< 0.05
2	CBR=19.225 - 0.188LL	0.846	0.716	0.706	1.1394	< 0.05
3	CBR=18.186 - 0.305PL	0.758	0.575	0.56	1.3948	< 0.05
4	CBR=17.061- 0.354PI	0.821	0.674	0.663	1.2206	< 0.05
5	CBR=28.188 - 0.67OMC	0.902	0.814	0.807	0.9228	< 0.05
6	CBR= -54.151+41.918MDD	0.894	0.799	0.792	0.9591	< 0.05

From the table above, based on the statistical parameters performed, it was noted that the CBR value correlates relatively better with liquid limit, optimum moisture content and maximum dry density, while the remaining parameters showed a weak relationship with CBR value. From the above results, based on the statistical parameters, coefficient of determination (R^2) and standard error the following equations ordered with decreasing order of coefficient of determination (R^2) and increasing order of standard error.

1. CBR = 28.188 - 0.67OMC, with R^2 = 0.814 (4.12)
2. CBR = -54.151 + 41.918MDD, with R^2 = 0.799 (4.13)
3. CBR = 19.225 - 0.188LL, with R^2 = 0.716 (4.14)
4. CBR = 17.061 - 0.354PI, with R^2 = 0.674 (4.15)
5. CBR = 18.186 - 0.305PL, with R^2 = 0.575 (4.16)
6. CBR = 38.021 - 0.371PP200, with R^2 = 0.492 (4.17)

From the ordered equations above, based on coefficient of determination (R^2) and standard error, I can summarize that model no.1 has the least standard error and the highest coefficient of determination (R^2) with level of significance less than 0.05. Therefore, it is chosen as best fit model from the developed single linear regression models.

The details of the statistical out-put of single linear regression indicates that the relationship developed between CBR and PP200, LL, PL, PI, OMC and MDD is significant ($p < 0.05$), and the detail outputs of the SPSS Software for the single linear regression analysis is presented under Appendix B to G of this thesis.

4.2.8.3.2 Summary of Models Developed from Multiple Linear Regression Analysis

The alternative models selected from the Multiple Linear Regression Analysis to decide the best fit model are summarized as the following table based on the statistical parameters taken from model summary and ANOVA result.

Table 4.13: Summary of Models Developed from Multiple Linear Regression Analysis

Model Code	Multiple Linear Regression Equations Developed Models	Statistical Parameters				
		R	R^2	R^2 adj.	Std.error	*P*-value
A	CBR = -27.303 - 0.095LL + 27.707MDD	0.943	0.89	0.882	1.1394	< 0.05
B	CBR = -12.124 - 0.077LL - 0.178OMC + 20.37MDD	0.948	0.899	0.887	0.7068	< 0.05
C	CBR = -6.63 - 0.033PP200 - 0.128PI - 0.216OMC + 18.34MDD	0.944	0.892	0.884	0.7205	< 0.05
D	CBR = -7.251- 0.102PL – 0.157OMC + 20.604MDD - 0.086PP200	0.941	0.885	0.86	0.7516	< 0.05

From the table above results, based on the coefficient of determination and standard error the following equations selected for models fitted with decreasing order of coefficient of determination (R^2) and increasing order of standard error.

1. CBR = -12.124 - 0.077LL - 0.178OMC + 20.37MDD, with R^2 =0.899 (4.18)
2. CBR = - 6.63 - 0.033PP200 - 0.128PI -0.216OMC + 18.34MDD, with R^2 =0.892 (4.19)
3. CBR = -27.303 - 0.095LL + 27.707MDD, with R^2 =0.89 (4.20)
4. CBR = -7.251-0.102PL-0.157OMC+20.604MDD-0.086PP200, with R^2 = 0.885 (4.21)

The other criteria used to select the best fit model among the predicted models is considering the statistical parameters F-value. As discussed so far under parametric statistical test, F-ratio represents the ratio of the improvement in prediction that results from fitting the model (regression) relative to the inaccuracy that still exists in the model (residual). In this case if the improvement due to fitting the regression of model is much greater than the inaccuracy within the model then the value of F-value will be larger. Based on the improvement in prediction (regression) and the inaccuracy exists in the model (residual), If the observed F-value is large in comparison to the tabulated value of F with n_1 and $n-n_1-1$ degree of freedom, the result is significant at level p (F) ≤ α (0.05), where n_1 is number of predictor in the model which represent degree of freedom of regression, n is number of sample size and p (F) is P-value of F-test [53]. The tabulated value of F (F-tab) is taken from Appendix A.4 F-distribution statistical table with p (F), n_1 (df of regression) and n_2 (df of residual) which is F (n_1, n2) [53]. Most values of F-tab. are obtained using interpolation. This is presented as table below.

Table 4.14: Summary of the selected SLRA and MLRA depending the ANOVA (F-test) for Testing Significance of Regression

Regression Type	Model Code	Source of Variability	Sum of Square	df	Mean Square	F-cal.	F-tab.	Results
SLRA	5	Regression	104.228	1	104.228	122.384	7.644	Significant
		Residual	23.846	28	0.852			
MLRA	A	Regression	113.949	2	56.975	108.912	5.498	Significant
		Residual	14.128	27	0.523			
	B	Regression	115.087	3	38.362	76.799	4.841	Significant
		Residual	12.987	26	0.5			
	C	Regression	115.097	4	28.754	55.431	4.18	Significant
		Residual	12.977	25	0.519			
	D	Regression	113.952	4	28.488	50.434	2.76	Significant
		Residual	14.121	25	0.565			

From the result table above, it is observed that the calculated F-value of all models is much greater than the tabulated F-value. Therefore, all models are significant at p (F) < α (0.05). However, in this case the criteria to select and judge the best fit model from all models is considering the value of the Residual Mean Square (RMS) of each model. The model with the smallest Residual Mean square (RMS) is usually preferred as the best fit model [53]. Hence, from the listed models, model B is preferred as best fit model having the smallest value of residual mean square to predict the outcome (dependent) variable.

4.2.8.4 Discussion on the Developed Equations of Regression analysis

4.2.8.4.1 Discussion on Single linear regression analysis

After carefully evaluating the data on the scatter plot and regression analysis models, the single linear regression analysis discovered that CBR is highly influenced by OMC by achieving a coefficient of determination value (R^2) of 0.814 and level of significance ($p < 0.05$) and least standard error. Based on this study it is observed that the effect of moisture content on CBR value is significant. This is because of CBR value is obtained at the OMC because at this moisture level, the maximum dry density (MDD) and the highest strength are achieved. The results indicated that the CBR provided a good correlation with OMC. The selected developed correlation model is given as:

CBR = 28.188 – 0.67OMC, with R^2 = 0.814, R^2 (adj.) = 0.807, N=30

4.2.8.4.2 Discussion on Multiple linear regression analysis

From the above alternatively selected developed correlation models from multiple linear regression analysis to decide the best fit model, comparing the statistical parameters such as coefficient of determination (R^2),the standard error and F-value, Model B is selected more preferably better than the remain developed correlation models. In the selected model as best fit (Model B) the predictors like liquid limit, optimum moisture content and maximum dry density are participated. In fact, in CBR laboratory test, CBR value is more sensitive to moisture content and dry density. That is, CBR value is dominantly affected by these parameters. The two former parameters are indicates that the effect of moisture content on CBR value, and the later one which is maximum dry density indicates the effect of dry density on CBR value. Therefore, depending on the above statistical parameters criteria and judgment, from multiple linear regression developed models, (Model B) is chosen as best fit model.

Finally, from the correlation analysis, the selected developed equations are: CBR = 28.188 – 0.67OMC, with the coefficient of determination, R^2 = 0.814 for single linear regression and CBR = -12.124 - 0.077LL – 0.178OMC + 20.37MDD, with the coefficient of determination, R^2 = 0.899 for multiple linear regression analysis respectively.

From these two models of regression analysis, it is observed that multiple linear regression has fairly good coefficient of determination than single linear regression analysis. Based on the statistical parameters performed such as coefficient of determination value (R^2), the standard error, F-value, RMS and the parameters contributed in the two models, comparing the two models, model obtained from multiple linear regression analysis is more preferably better than that of single linear regression model. Therefore, model CBR= -12.124 - 0.077LL – 0.178OMC + 20.37MDD, with the coefficient of determination $R^2 = 0.899$ is preferably selected for further validation. The details of the statistical out-put of multiple linear regression indicates that the relationship developed between CBR and LL and compaction characteristics (OMC and MDD) is statistically significant ($p < 0.05$) and the detail outputs of the SPSS Software for this multiple linear regression model is presented under Appendix H of this thesis.

4.2.9 Validation of the Developed Equation

Assessing the accuracy of a model across different samples is known as cross-validation [45]. To check the validity of developed model a separate set of soil samples were tested. In this section, the developed equations is tried to validate using nine (9) control tests. To verify the suitability of the developed correlation equation, the predicted CBR is determined using control test data to compare it with the actual or experimentally observed CBR value.

The sample data that is used as a control test is obtained by conducting different tests such as Sieve analysis, Atterberg's limits, Compaction and California Bearing Ratio (CBR) tests on different location of Seka soil sample. Summary of laboratory test results is given as follows:

Table 4.15: Summary of laboratory results for control tests

Test Pit	Depth (m)	Control Test Results						
		PP200 (%)	Atterberg's Limits Test Result			Modified Proctor Compaction Test Result		CBR Value @ 95% MDD (%)
			LL (%)	PL (%)	PI (%)	OMC (%)	MDD (g/cc)	
TP11 (CT)	1	85.6	67.8	36.5	31.3	32.5	1.47	6.7
	2	83.2	66.5	34.6	31.9	31.2	1.49	7.5
	3	82.4	65.6	34.2	31.4	28.5	1.51	8.0
TP12 (CT)	1	88.6	70.5	38.8	31.7	32.8	1.44	5.6
	2	86.5	69.2	37.2	32.0	31.8	1.46	6.4
	3	85.2	68.8	36.4	32.4	30.6	1.49	7.8
TP13 (CT)	1	89.6	71	38.1	32.9	33.6	1.43	5.4
	1	86.3	69.8	37.6	32.2	31.4	1.47	6.5
	3	83.8	67.6	35.8	31.8	31.2	1.48	7.4

4.2.10 Cross Validation result

For validation test, the selected control test covers 30% of the training data. Substituting the values of the LL, OMC and MDD in model, CBR = -12.124 - 0.077LL – 0.178OMC +20.37MDD, with $R^2 = 0.899$ which is chosen as best fit and selected for validation, the CBR is predicted. The following table shows the percentage of average variation of controlled test.

Table 4.16: Validation result of the developed equation

Test Pit	Depth (m)	Actual CBR Value (%) **[A]**	Predicted CBR Value (%) **[B]**	Variation **| [(A-B)/A]|*100** (%)
TP11 (CT)	1	6.7	6.81	1.71
	2	7.5	7.55	0.71
	3	8.0	8.51	6.38
TP12 (CT)	1	5.6	5.94	6.11
	2	6.4	6.63	3.55
	3	7.8	7.48	4.07
TP13 (CT)	1	5.4	5.56	2.91
	2	6.5	6.86	5.48
	3	7.4	7.26	1.83
			Av. Variation (%)	3.64

4.2.10.1 Discussion on Cross Validation result

From the above cross validation result, the total percentage of variation is 3.64% which indicate that there is a good prediction of the dependent variable. This percentage of variation is occurred due to the location of the control test pit is different from the samples considered in the correlation, and also in nature the soil behavior is vary from place to place and season to season. In general, I can conclude that the statistical regression analysis indicates the correlation may give 96% accuracy in the determination of the CBR value for the controlled tests. However, before using this developed correlation equation for practical purpose, it needs an improvement using with large number of samples and more advanced methods of regression and correlation analysis.

4.2.11 Comparison of Experimental and Predicted CBR Value from the Present Study

The following table shows the percentage of average variation of the experimental and predicted CBR value of the present study using the selected predicted regression model.

Table 4.17: Comparison of Experimental and Predicted CBR Value from the Present Study

Sample No.	Independent Variables used in the Current Predicted Model			Developed Model		
	LL (%)	OMC (%)	MDD (g/cc)	Actual CBR value (%)	Predicted CBR value	Variation
				A	**B**	**|[(A-B)/A]*100 (%)**
1	60.8	32.7	1.46	7.0	7.11	1.63
2	56.4	32.5	1.45	7.4	7.28	1.56
3	53.6	28.8	1.50	8.0	9.18	14.72
4	70.8	32.3	1.48	6.4	6.82	6.60
5	67.6	31.5	1.49	7.6	7.42	2.43
6	64.9	28.2	1.51	8.2	8.62	5.10
7	49.6	27.5	1.51	10.5	9.92	5.52
8	48.4	27.2	1.53	11.2	10.47	6.48
9	46.8	26.2	1.54	12.8	10.98	14.23
10	71.2	35.0	1.44	4.8	5.50	14.51
11	73.5	33.1	1.46	6.2	6.06	2.18
12	69.4	31.2	1.49	7.2	7.33	1.80
13	69.6	32.0	1.46	7.6	6.56	13.67
14	66.6	29.7	1.49	7.8	7.81	0.16
15	60.2	27.6	1.52	9.0	9.29	3.22
16	60.8	33.5	1.46	6.8	6.97	2.52
17	50.0	27.6	1.50	8.4	9.67	15.10
18	46.0	26.4	1.53	10.0	10.80	8.01
19	70.0	34.2	1.39	5.2	4.71	9.37
20	68.0	29.8	1.47	7.2	7.28	1.10
21	48.5	28.7	1.51	10.4	9.79	5.85
22	64.4	34.5	1.42	6.2	5.70	8.04
23	60.8	30.8	1.43	6.6	6.84	3.65
24	57.5	30.5	1.46	6.8	7.76	14.11
25	74.0	34.5	1.38	4.4	4.15	5.74
26	73.0	35.4	1.43	4.8	5.08	5.89
27	66.6	31.6	1.45	6.0	6.66	10.99
28	76.0	35.6	1.37	3.4	3.59	5.71
29	74.8	33.6	1.41	5.6	4.86	13.26
30	73.0	31.5	1.47	6.8	6.59	3.06
Average Variation (%)						6.87

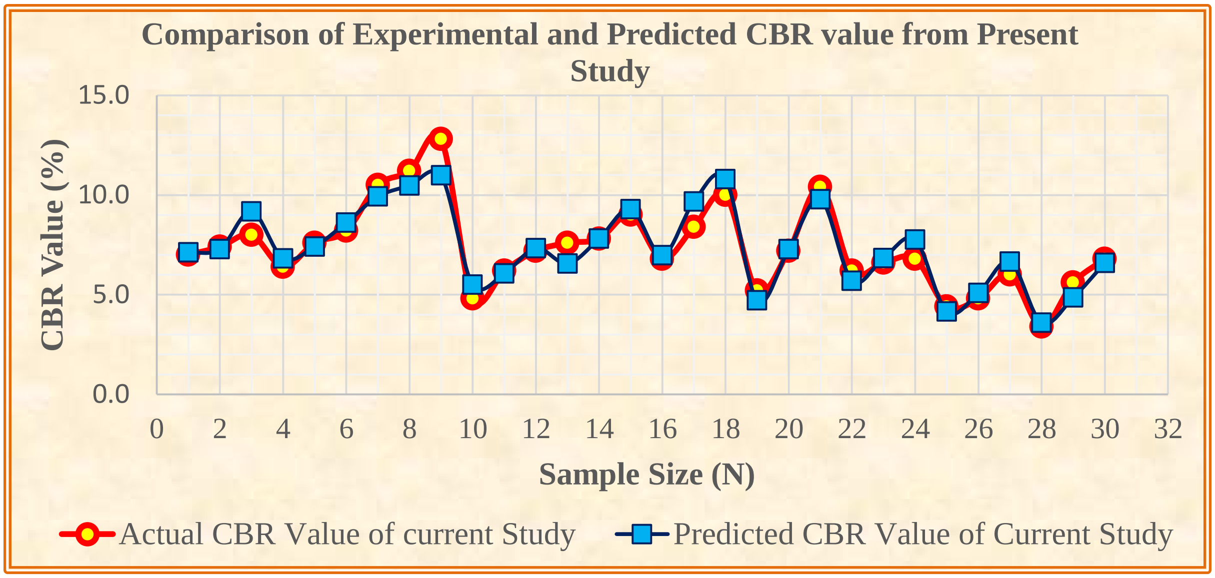


Figure 4.16: Graphical Comparison of Experimental and Predicted CBR Value from the Present Study

From the table above, the developed correlation predicted the CBR value is varied with an average variation of 7% from the actual CBR value. From the graph the trend curves of the experimental and predicted CBR value are following each other with small deviation. This small variation indicate that there is a good prediction of the CBR values of soil in the study area using a predicted model.

4.2.12 Evaluation of the Developed Model Using Previous Existing Data

To seek and verify the validity of the predicted model as it is applicable to use for other places of soil, it should be compared with the available data of soil properties investigated by few investigators for predicting CBR value on the basis of the parameters participated in the predicted model [54]. This means the experimental parameters participated in the current best fit model and the actual CBR value obtained by the previous researchers was taken then substituting these parameters value in the current best fit model, the CBR value was predicted. Then the predicted CBR value was compared with the experimental CBR value obtained by the previous researchers. Finally, based on the variation occurred the applicability of the current model for other area of soil was identified. For this purpose the tested value of CBR in soaked condition, and Liquid Limit and compaction characteristics (OMC and MDD) reported by Yared Leliso [18] were used for the validation of the current predicted model. The results of the actual soaked CBR values and the predicted value after substituting parameters such as

LL, OMC and MDD reported by [18] in the current best fit model, and the variation is presented in table below. Note here the Actual CBR value (%) is reported by [18].

Table 4.18: Validation of the Developed Model Using Existing Correlation data

Sample No.	Experimental Variables reported by Yared Leliso and used in the Present Predicted Model			Existing Study by Yared Leliso		
				Actual CBR value (%)	Predicted CBR value by Present Study	Variation
	LL (%)	OMC (%)	MDD (g/cc)	**A**	**B**	**|[(A-B)/A]*100 (%)**
1	50.0	23.3	1.55	6.0	11.45	90.87
2	43.0	21.9	1.60	10.0	13.26	32.59
3	53.0	20.9	1.57	9.2	12.06	31.04
4	48.0	20.6	1.56	6.2	12.29	98.23
5	55.0	20.4	1.54	6.4	11.38	77.81
6	46.0	20.2	1.59	7.4	13.13	77.39
7	60.0	24.3	1.51	3.3	9.69	193.62
8	66.0	29.2	1.50	6.1	8.15	33.63
9	61.0	27.8	1.53	5.4	9.40	74.01
10	63.0	29.2	1.53	6.1	8.99	47.43
11	54.0	23.2	1.59	7.3	11.98	64.06
12	59.0	23.8	1.55	7.8	10.67	36.80
13	52.0	27.6	1.53	9.4	10.13	7.72
14	57.0	24.2	1.50	8.4	9.73	15.89
15	61.0	23.3	1.58	4.1	11.22	173.57
16	70.0	27.8	1.48	2.2	7.69	249.33
17	56.0	22.2	1.64	7.3	13.02	78.35
18	60.0	26.0	1.53	5.2	9.79	88.35
19	63.0	27.7	1.56	4.6	9.87	114.60
20	54.0	23.4	1.61	8.4	12.35	47.01
21	59.0	24.5	1.58	4.7	11.16	137.37
22	61.0	19.0	1.57	4.3	11.78	173.90
23	67.0	22.0	1.54	6.2	10.17	64.05
24	62.0	30.2	1.57	6.4	9.71	51.68
25	72.0	30.2	1.48	2.8	7.10	153.71
26	60.0	24.2	1.52	5.8	9.91	70.88
27	68.0	28.4	1.50	3.6	8.14	126.11
28	63.0	29.3	1.49	5.3	8.16	53.98
29	59.0	22.9	1.50	3.7	9.81	165.18
30	65.0	24.1	1.48	3.2	8.73	172.78
Average Variation (%)						93.40

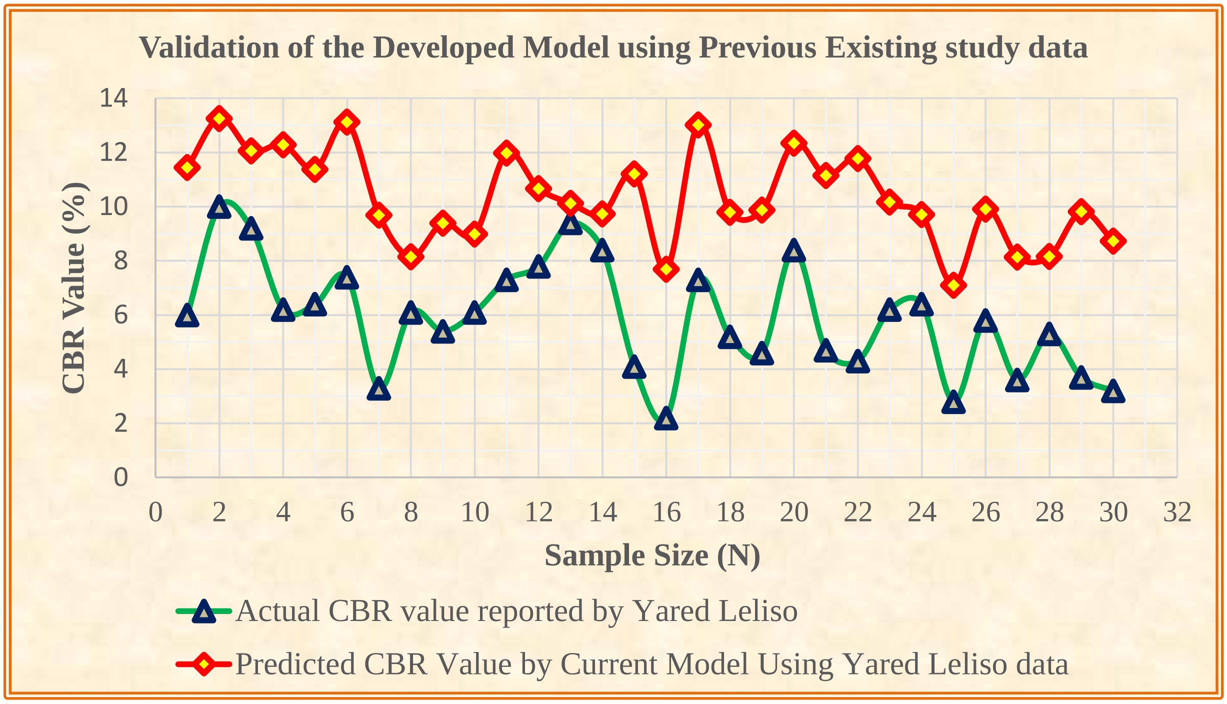


Figure 4.17: Graphical Comparison of experimental CBR value from existing correlation and predicted CBR value from present developed model

4.2.12.1 Discussion on Comparison of the developed model with previous existing correlations

As observed from the table above, it is observed that the predicted value of CBR from the current model using existing data is relatively larger than the experimental CBR value reported by the previous researcher.

From the figure above, even the trend line of the actual CBR value reported by Yared Leliso and the Predicted CBR value from the current model using the existing reported data follows the same pattern of curve, there is a large reasonable variation. This is may be due to the difference in test procedures and the geotechnical properties of the soil where this correlation was developed. This indicate that correlation developed for a certain soil is not applicable for other soil. However, if further validation performed with different areas of soil properties the developed model might be establish good prediction of CBR value for similar properties of soils from another site.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The research was conducted to predict the California bearing ratio (CBR) value from index properties of soil such as percent passing sieve no.200, LL, PL, PI, OMC and MDD. To achieve the objectives of the study, about thirty soil samples extracted from different location of the town and laboratory tests were carried out. Using the obtained test results a single and multiple linear regressions were analyzed and a relationship was developed that predict CBR value in terms of PP200, LL, PL, PI, OMC and MDD.

Depending on the results and discussions presented in this study the following conclusions were brought out:

From the scatter plot, it is observed that the percent passing sieve no.200, LL, PL and PI have a weak negative relationship and OMC has a strong negative relationship with a dependent variable (CBR), however, MDD has a strong positive relationship with the CBR. In another word, the effect of fine, plasticity index, liquid limit, plastic limit and optimum moisture content have negative effect on CBR. That means if fine content, liquid limit, plastic limit, plasticity index, optimum moisture content tends to increase, the CBR value tends to decrease. Therefore, from this it can be concluded that the presence of much fine particles, high water content and plasticity affect the soil strength. But in the case of maximum dry density (MDD), it is observed that MDD has positive effect on CBR which indicates increasing maximum dry density gives better subgrade strength, (CBR) value.

Depending on both the graphical and statistical (analytical) normality test result, the normality test result of the collected samples fulfill the basic assumption of normality test.

Based on the multicollinearity test result there is no collinearity problem between the independent variables like PP200, OMC and MDD, but there is collinearity problem between the atterberg parameters (LL, PL and PI). Therefore, we can safely conclude that the predictors which have multicollinearity problem cannot be participated at the same time in multiple regression modeling analysis.

From among the single linear regression analysis, the correlation between CBR and optimum moisture content (OMC) has strong correlation than the other predicting parameters which is expressed in the following relationship:

CBR = 28.188 – 0.67OMC, with R^2 = 0.814, R^2 (adj.) = 0.807

From among the developed multiple regression models, after going through a number of alternative combinations of different predictors, relatively an improved correlation than the single regression is provided between CBR and the combination of LL,OMC and MDD. This happening indicates that, the compaction characteristics (Maximum dry density and Optimum moisture Content) and Liquid Limit are more interested parameters that make a significant contribution to predicting the CBR value. The develop correlation equation with CBR is expressed in the following relationship:

CBR = -12.124 - 0.077LL – 0.178OMC + 20.37MDD, with R^2 = 0.899, R^2 (adj.) = 0.887

From control tests the predicted CBR has an average variation of 3.64% compared to the actual CBR value. This indicates the correlation gives fairly good results.

The developed correlation is predicted the CBR value with average variation of 7% from the actual CBR value which indicate that there is a good prediction of the CBR values of soil in the study area. It was observed that the actual soaked CBR value and the predicted CBR values are close to each other hence the proposed correlation is acceptable and could be applied for the prediction of the CBR values in different civil engineering practices in the study area.

From the existing correlation, it was verified by previous study undertaken by Yared L. [18]. According to the observed comparison the result varied with large variation which indicate that correlation developed for a certain soil is not applicable for other soil. Even though the predicted model presented in the present study can be effectively used for preliminary prediction of CBRs value for fine grained locally available soils in study area. However, before using this developed correlation equation for practical purpose such as design, it needs an improvement using with large number of samples and more advanced methods of regression and correlation analysis.

5.2 Recommendations for the future

In this research study, it is observed that there is fair good correlation between California Bearing ratio value and the compaction characteristics (Maximum dry density and Optimum moisture Content) and Liquid limit of soils found in Seka town.

Following are some of the recommendations for future research study in relation to the subject study to get a more interesting and reliable correlation in the future.

- To get better result, further improvement in the developed equation is possible by incorporating large samples size covering the whole study area.
- For better understanding the relationship between the CBR value and Index Properties of Soil, both the prediction of soaked and unsoaked CBR values from the index properties of soil shall be checked comparatively.
- Laboratory tests will also be carried out on different geological formations in order to develop standard models for determining approximate values of strength properties of the respective formations.
- It is recommended to collect more data in the form of data base covering wide ranges in Ethiopia according to the soil type to get a common appropriate correlation between the California Bearing Ratio (CBR) value and Index Properties of soil through the use of advanced software tools.

REFERENCES

[1] B. J.E., Foundation Analysis and Design, 4th Edition,, McGraw Hill,, 1988.

[2] G. Ramasubbarao and S. G. Siva, "Predicting Soaked CBR Value of Fine- Grained Soils Using Index and Compaction Characteristics.," *Jordan Journal of Civil Engineering.*, vol. 7, 2013.

[3] C. Venkatasubramanian and G. Dhinakaran, "ANN Model for Predicting CBR from Index Properties of Soil," *International Journal of Civil and Structural Engineering*, vol. 2, pp. 605-611, 2011.

[4] N. Shirur and S. Hiremath, "Establishing Relationship between CBR Value and Physical Properties of Soil," *IOSR Journal of Mechanical and Civil Engineering*, vol. 11, pp. 26-30, 2014.

[5] J. E. Bowles , Engineering Properties of Soils and Their Measurement, Singapore, second edition: McGraw-Hill, 1984.

[6] O. Dr. Ndefo , "Causes of Highway Failures in Nigeria.," *International Journal of Engineering Science and Technology (IJEST)*, vol. 11, pp. 4695-4703, November 2012.

[7] Roy , T.K; Chattapadhyay , B. ; Roy S., K,, "California Bearing Ratio, Evaluation, and Estimation: A Study of Comparison.," *IGC-,IIT*, pp. 19-22, 2010.

[8] N. S. V. K. Rao, FOUNDATION DESIGN:THEORY AND PRACTICE, Malaysia, 2010.

[9] Sorensen K.k.a.O., N, "Correlation between drained shear strength and plasticity index of undisturbed over consolidated clays," *18th International Conference on Soil Mechanics and Geotechnical Engineering*, 2013.

[10] Dino Abdela, "A Study on Correlation of California Bearing Ratio (CBR) With Index Properties of Soils on Welkite –Arekit-Hossana Road," *Thesis Work School of Civil and Environmental Engineering Jimma University*, 2016.

[11] S. Zohib , "Correlation of CBR with Index Properties of Soil," *International Journal of Civil Engineering and Technology IJCIET*, vol. 7, no. 5, pp. 57-62, September-October 2016 .

[12] SABS:South African Bureau of Standards, "The determination of the California Bearing Ratio," *SANS Part GR40 (Draft)*, 2008.

[13] shworth R.A, Highway engineering, London: Heinemann Educational Book, 1972.

[14] D. Croney and P. Croney, The Design and performance of road pavements, London: Mc Graw Hill Book Company, 1991.

[15] AASHTO: Standard Specifications for Transportation Materials and Methods of Sampling and Testing Part II Methods of Sampling and Testing, Washington: 25thEdition.American Association of State Highway and Transportation Officials, 2005.

[16] M.M and E. Zumrawi, "Prediction of In-situ CBR of Subgrade Cohesive Soils from Dynamic Cone Penetrometer and Soil Properties," *IACSIT International Journal of Engineering and Technology,* vol. 6, pp. 439-442, 2014.

[17] N. BaoThach and M. Abbas , "Prediction of California Bearing Ratio from Physical Properties of Fine-Grained Soils," *World Academy of Science, Engineering and Technology International Journal of Civil, Structural, Construction, and Architectural Engineering,* vol. 9, pp. 132-137, 2015.

[18] Yared Leliso , "Correlation of CBR Value with Soil Index Properties for Addis Ababa Subgrade Soils," *Thesis Work Addis Ababa University,* 2013.

[19] "Ethiopian Road Authority (ERA) Site Investigation Manual," 2002.

[20] Y. Desalegn, "Developing Correlations between DCP and CBR for Locally Used Sub grade Materials," *Thesis Work, Addis Ababa University,* 2012.

[21] K. R. Arora, Soil Mechanics and Foundation Engineering, Delhi: Re-print Standard Publishers Distributor Nai Sadak, 2004.

[22] Z. U. Rehman, U. Khalid , K. Farooq and H. Mujtaba, "Prediction of CBR Value from Index Properties of different Soils," *Technical Journal, University of Engineering and Technology (UET) Taxila,* vol. 22, pp. 17-26, 2017.

[23] P. G. Rakaraddi and Vijay Gomarsi, "A correlation between CBR value and index properties," *International Journal of Research in Engineering and Technology,* 2015.

[24] H. R. Srinivasa , N. Sureka and S. Gangadhara , "Development of Regression Equations to Predict CBR of Black Cotton Soils of Karnataka," *International Journal of Civil Engineering Research,* vol. 7, pp. 135-152, 2016.

[25] I. Faisal, K. Aneel and A. M, "Co-Relationship between California Bearing Ratio and Index Properties of Jamshoro Soil," *Mehran University Research Journal of Engineering and Technology,* vol. 37, pp. 177-190, 2018.

[26] B. Yildrim and O. Gunaydin, ""Estimation of CBR by soft computing systems." Expert Systems with Applications Elsevier," vol. 38 , pp. 6381-6391, 2011 .

[27] https://en.wikipedia.org/10/june/2019. [Online]. [Accessed 10 June 2019].

[28] A. S. Singh and M. B. Masuku , "SAMPLING TECHNIQUES AND DETERMINATION OF SAMPLE SIZE IN APPLIED STATISTICS RESEARCH," *International Journal of Economics, Commerce and Management*, vol. II, no. 11, November 2014.

[29] F. Nick , H. Amanda and . M. Nigel, "Sampling and Sample Size Calculation," *The NIHR Research Design Service for Yorkshire & the Humber* , 2009.

[30] ASTM, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass in D 2216 – 98, West Conshohocken., 1998.

[31] R. Krishna , Engineering Properties of Soils Based on Laboratory Testing, UIC, 2002.

[32] J. Mittal , Sand Shukla , soil testing for Engineers, Delhi (India): Romesh ChanderKhannaPublishers, 2000.

[33] k. R. Arora, soil mechanics and foundation engineering, Delhi: standard publisher’s distributors, 2003.

[34] M. Budhu, Soil Mechanics and Foundations, 3rd Ed ed., New York John Wiley & Sons, 2011.

[35] B. Das, Principles of Geotechnical Engineering, 7th ed ed., Stamford Cengage Learning, 2010.

[36] J. Briaud, Geotechnical Engineering: Unsaturated and Saturated Soils, United States of America John Wiley & Sons, Inc, 2013.

[37] Pavement Manual, July 4,2007.

[38] B. Das , Advanced Soil Mechanics, 3rd ed ed., New York , USA Taylor & Francis eLibrary, 2008.

[39] V. N. Murthy, Soil Mechanics and Foundation Engineering, 5th ed. ed., new york: UBS Publishers Distributors Ltd, 2001.

[40] AASHTO T 180, Standard Method of Modified Compaction Test for Soil.

[41] AASHTO T 193-3, Standard Method of Test for California Bearing Ratio (CBR) Value of Soils in Laboratory.

[42] B. G. Look, Handbook of Geotechnical Investigation and Design Tables, Second Edition ed., Australia, 2014.

[43] ASTM D4429-93, Standard Method of Test for CBR (California Bearing Ratio) Value of Soils in Place..

[44] H. Park, "Univariate analysis and normality test using SAS, Stata, and SPSS.", Indiana University, 2008.

[45] A. FIELD, DISCOVERING STATISTICS USING SPSS, THIRD EDITION ed., London:Sage, 2009.

[46] K. R. Das and A. M. Rahmatullah Imon, " Brief Review of Tests for Normality," *American Journal of Theoretical and Applied Statistics,* January 27, 2016 .

[47] P. Samuels and E. Marshall, "Checking normality in SPSS," *statstutor community project.*

[48] F. Graybill and H. Iyer , Regression analysis concepts and application., California: Wadsworth publishing company, 1962.

[49] N. Draper and H. Smith , Applied Regression Analysis, United States of America:John Wiley & Sons.inc., 1998.

[50] D. Montgomery and G. Runger , Applied Statistics and Probability for Engineers., United States of America: John Wiley & Sons, Inc., 2002.

[51] A. Elliott and W. Woodward , Statistical analysis quick reference guidebook, 2007.

[52] ASTM, Standard Practice for Calculating Sample Size to Estimate,with specified precision,the average for a characteristic lot or processin, West Conshocken, E122-09 2009 .

[53] S. Chatterjee and . S. H. Ali, Regression Analysis By Example, Fifth Edition ed., Canada, 2012.

[54] T. Datta and B. Chottopadhyay, "CORRELATION BETWEEN CBR AND INDEX PROPERTIES OF SOIL," *Proceedings of Indian Geotechnical Conference,* pp. (Paper No. A-350), 15-17 December 2011 .

APPENDIXES

Appendix A

Normality Test Result of Skewness and Kutrosis Coefficient

Case Processing Summary

Variables	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
CBR	30	100.0%	0	0.0%	30	100.0%
PP200	30	100.0%	0	0.0%	30	100.0%
LL	30	100.0%	0	0.0%	30	100.0%
PL	30	100.0%	0	0.0%	30	100.0%
PI	30	100.0%	0	0.0%	30	100.0%
OMC	30	100.0%	0	0.0%	30	100.0%
MDD	30	100.0%	0	0.0%	30	100.0%

Statistics

		CBR	PP200	LL	PL	PI	OMC	MDD
N	Valid	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0
Mean		7.343	82.617	63.093	35.583	27.477	31.123	1.4670
Std. Error of Mean		.3837	.7248	1.7242	.9546	.8908	.5168	.00818
Median		7.100	82.250	65.750	35.500	28.450	31.500	1.4650
Mode		6.8	78.4[a]	60.8	29.8[a]	19.7[a]	27.6[a]	1.46
Std. Deviation		2.1015	3.9699	9.4439	5.2284	4.8790	2.8306	.04481
Variance		4.416	15.760	89.187	27.337	23.805	8.012	.002
Skewness		.650	.059	-.501	.138	-.668	-.162	-.436
Std. Error of Skewness		.427	.427	.427	.427	.427	.427	.427
Kurtosis		.562	-.550	-1.054	-1.311	-.383	-1.120	-.369
Std. Error of Kurtosis		.833	.833	.833	.833	.833	.833	.833
Range		9.4	15.9	30.0	16.7	17.8	9.4	.17
Minimum		3.4	74.8	46.0	27.9	17.8	26.2	1.37
Maximum		12.8	90.7	76.0	44.6	35.6	35.6	1.54
Percentiles	25	6.150	80.000	55.700	30.125	25.525	28.575	1.4375
	50	7.100	82.250	65.750	35.500	28.450	31.500	1.4650
	75	8.250	85.875	70.900	40.600	30.900	33.525	1.5025

a. Multiple modes exist. The smallest value is shown

Appendix B

Single Regression Analysis Result between CBR and PP200

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PP200[b]	.	Enter

a. Dependent Variable: CBR
b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.701[a]	.492	.474	1.5243	1.406

a. Predictors: (Constant), PP200
b. Dependent Variable: CBR

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	63.018	1	63.018	27.123	.000[b]
	Residual	65.055	28	2.323		
	Total	128.074	29			

a. Dependent Variable: CBR
b. Predictors: (Constant), PP200

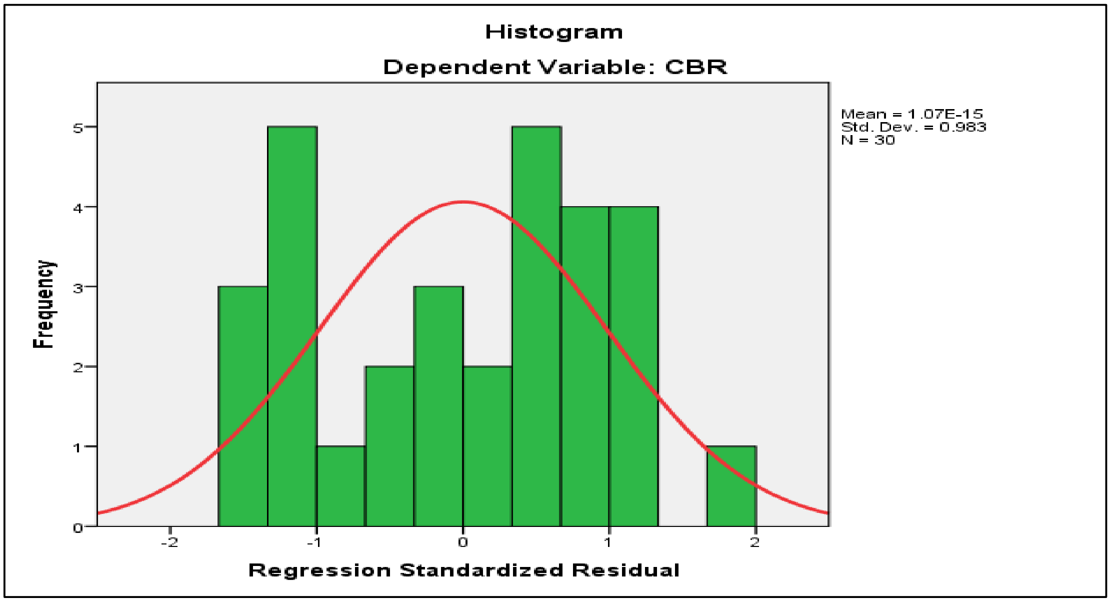
Coefficients[a]

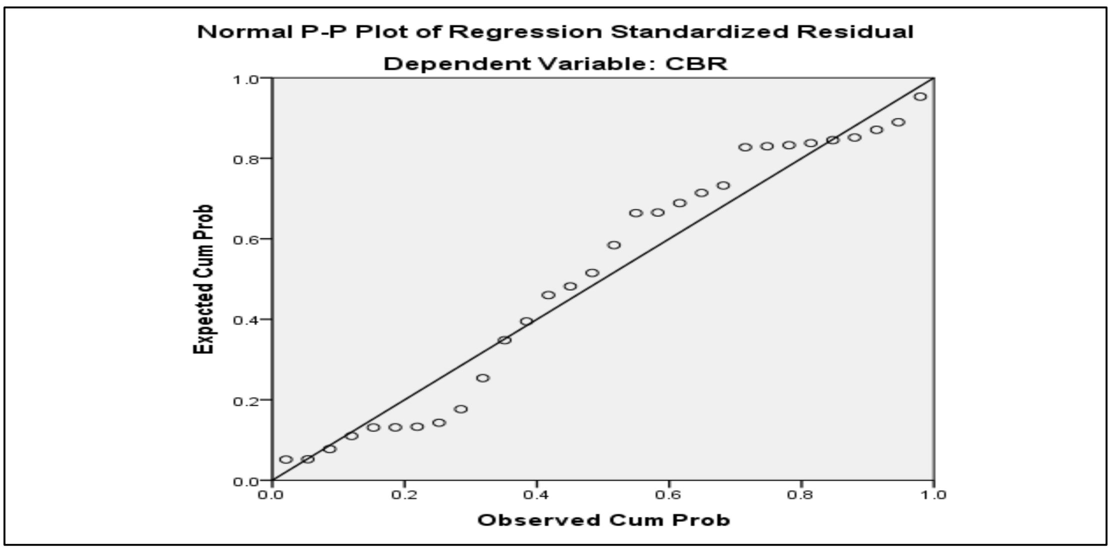
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	38.021	5.897		6.447	.000	25.941	50.101		
	PP200	-.371	.071	-.701	-5.208	.000	-.517	-.225	1.000	1.000

a. Dependent Variable: CBR

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.342	10.246	7.343	1.4741	30
Residual	-2.4837	2.5541	.0000	1.4978	30
Std. Predicted Value	-2.036	1.969	.000	1.000	30
Std. Residual	-1.629	1.676	.000	.983	30

a. Dependent Variable: CBR





Appendix C

Single Regression Analysis Result between CBR and LL

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	LL[b]	.	Enter

a. Dependent Variable: CBR

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.846[a]	.716	.706	1.1394	1.007

a. Predictors: (Constant), LL

b. Dependent Variable: CBR

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	91.721	1	91.721	70.646	.000[b]
	Residual	36.353	28	1.298		
	Total	128.074	29			

a. Dependent Variable: CBR

b. Predictors: (Constant), LL

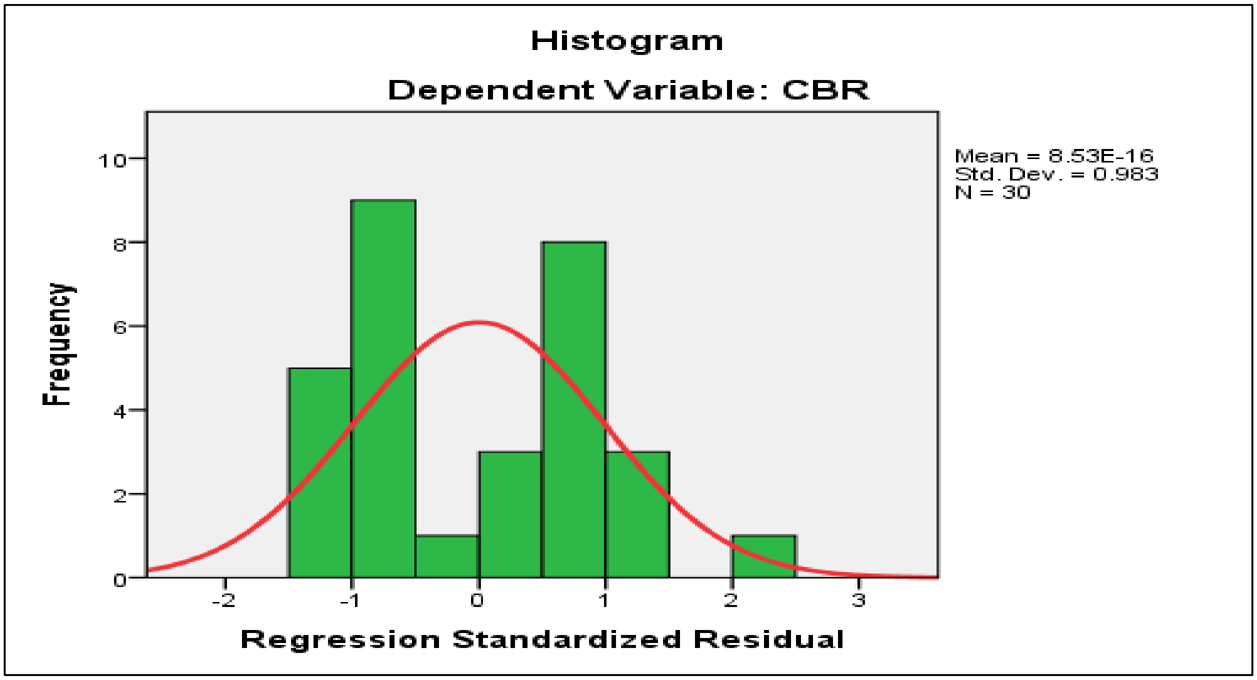
Coefficients[a]

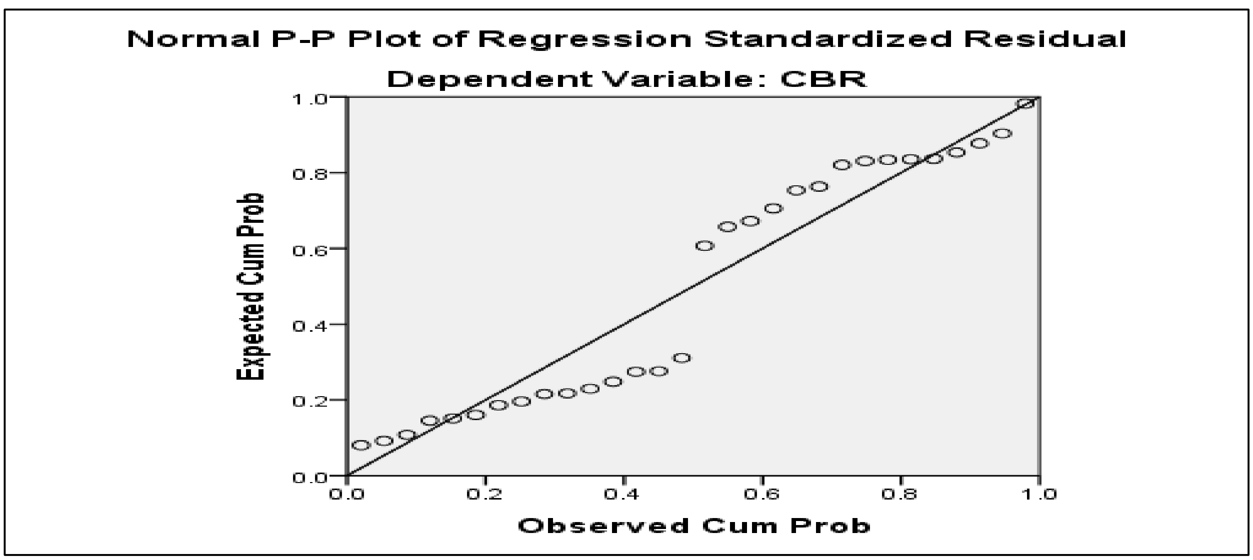
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	19.225	1.429		13.455	.000	16.298	22.152		
	LL	-.188	.022	-.846	-8.405	.000	-.234	-.142	1.000	1.000

a. Dependent Variable: CBR

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.913	10.562	7.343	1.7784	30
Residual	-1.5966	2.3884	.0000	1.1196	30
Std. Predicted Value	-1.367	1.810	.000	1.000	30
Std. Residual	-1.401	2.096	.000	.983	30

a. Dependent Variable: CBR





Appendix D

Single Regression Analysis Result between CBR and PL

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	PL[b]	.	Enter

a. Dependent Variable: CBR

b. All requested variables entered.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.758[a]	.575	.560	1.3948	.709

a. Predictors: (Constant), PL

b. Dependent Variable: CBR

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	73.604	1	73.604	37.836	.000[b]
	Residual	54.470	28	1.945		
	Total	128.074	29			

a. Dependent Variable: CBR

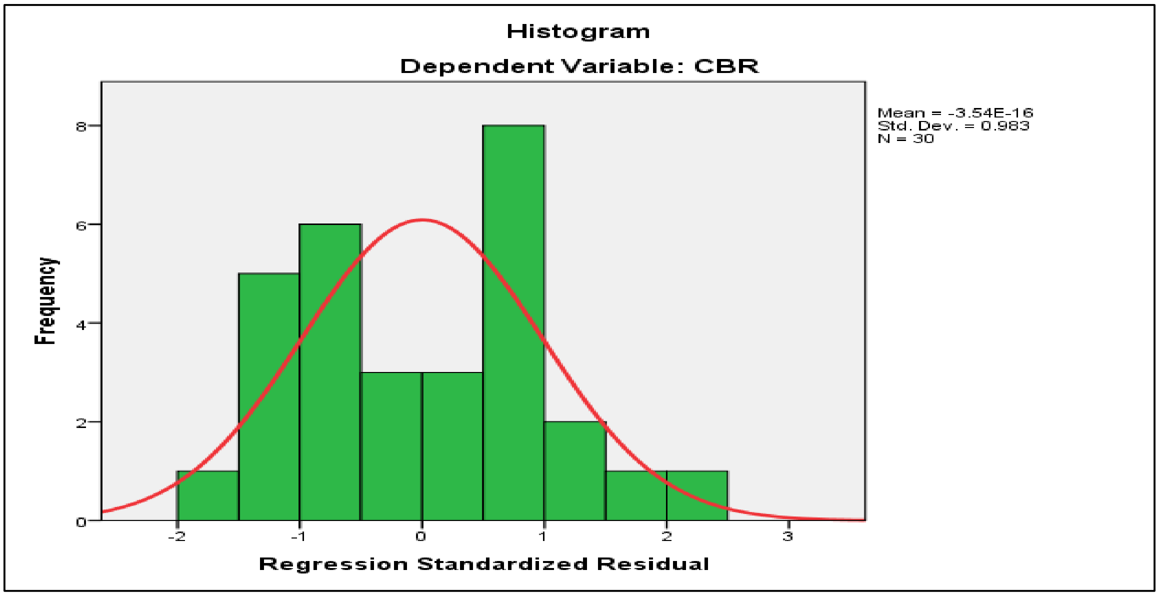
b. Predictors: (Constant), PL

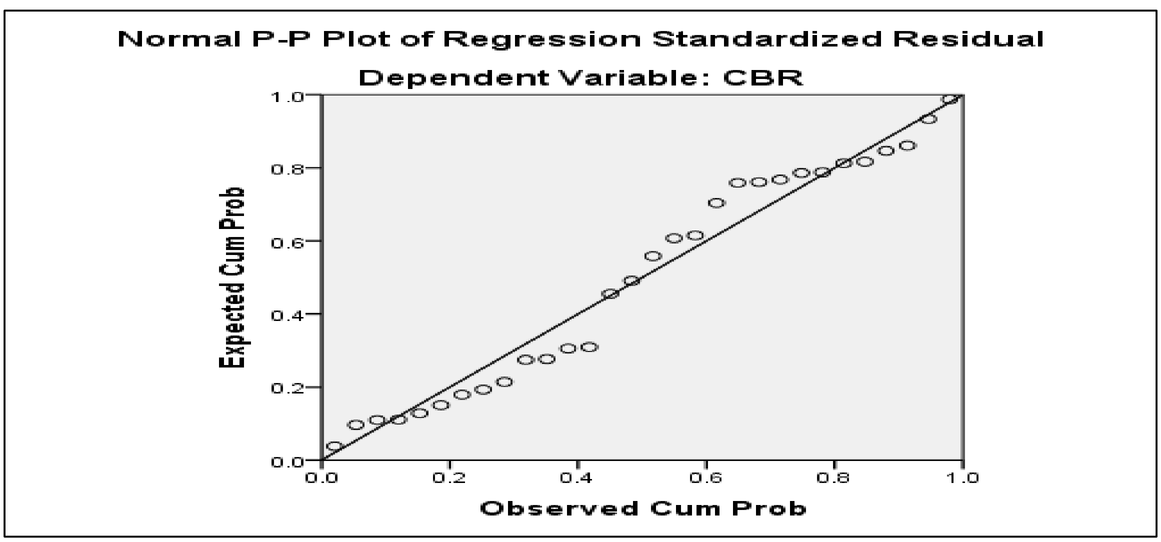
Coefficients[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	18.186	1.781		10.211	.000	14.538	21.834		
	PL	-.305	.050	-.758	-6.151	.000	-.406	-.203	1.000	1.000

a. Dependent Variable: CBR

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.596	9.684	7.343	1.5931	30
Residual	-2.4757	3.1155	.0000	1.3705	30
Std. Predicted Value	-1.725	1.470	.000	1.000	30
Std. Residual	-1.775	2.234	.000	.983	30

a. Dependent Variable: CBR





Appendix E

Single Regression Analysis Result between CBR and PI

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	PI[b]	.	Enter

a. Dependent Variable: CBR

b. All requested variables entered.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.821[a]	.674	.663	1.2206	1.627

a. Predictors: (Constant), PI

b. Dependent Variable: CBR

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	86.355	1	86.355	57.959	.000[b]
	Residual	41.718	28	1.490		
	Total	128.074	29			

a. Dependent Variable: CBR

b. Predictors: (Constant), PI

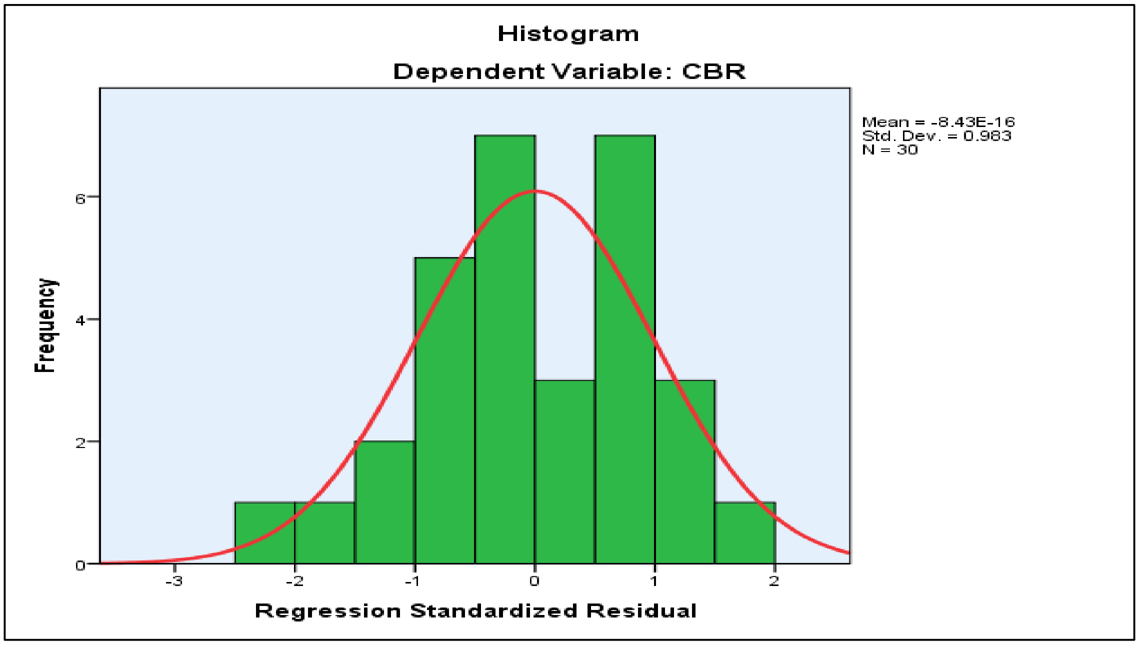
Coefficients[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	17.061	1.296		13.167	.000	14.407	19.716		
	PI	-.354	.046	-.821	-7.613	.000	-.449	-.259	1.000	1.000

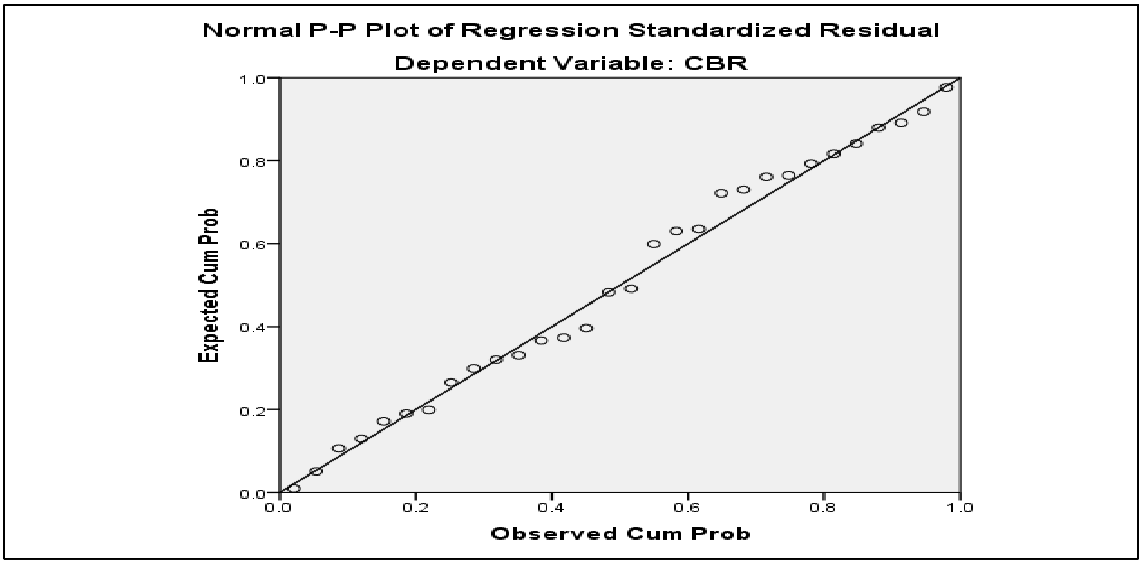
a. Dependent Variable: CBR

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.470	10.766	7.343	1.7256	30
Residual	-2.8534	2.4232	.0000	1.1994	30
Std. Predicted Value	-1.665	1.983	.000	1.000	30
Std. Residual	-2.338	1.985	.000	.983	30

a. Dependent Variable: CBR





Appendix F

Single Regression Analysis Result between CBR and OMC

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	OMC[b]	.	Enter

a. Dependent Variable: CBR

b. All requested variables entered.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.902[a]	.814	.807	.9228	1.819

a. Predictors: (Constant), OMC

b. Dependent Variable: CBR

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	104.228	1	104.228	122.384	.000[b]
	Residual	23.846	28	.852		
	Total	128.074	29			

a. Dependent Variable: CBR

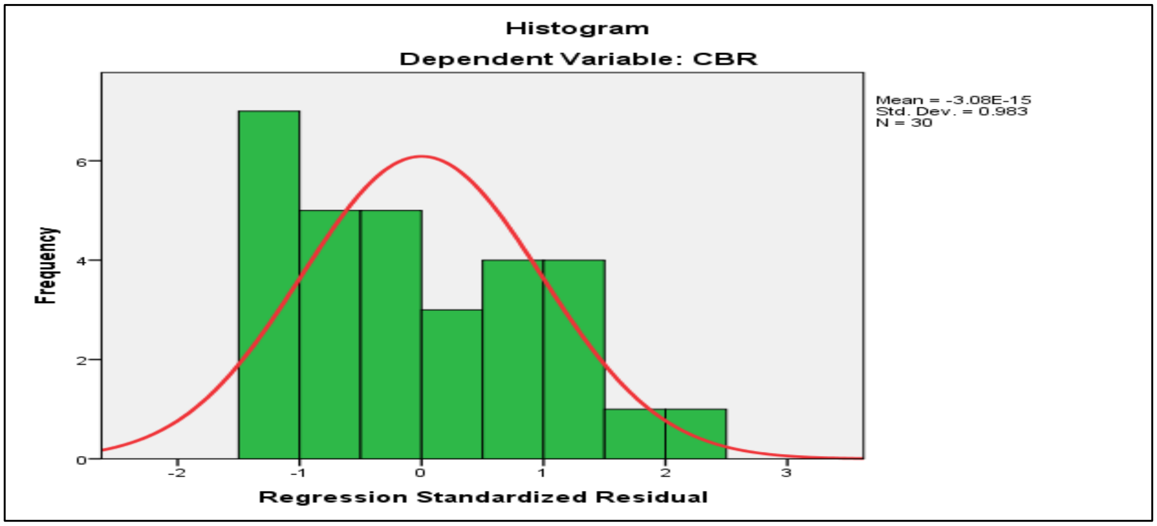
b. Predictors: (Constant), OMC

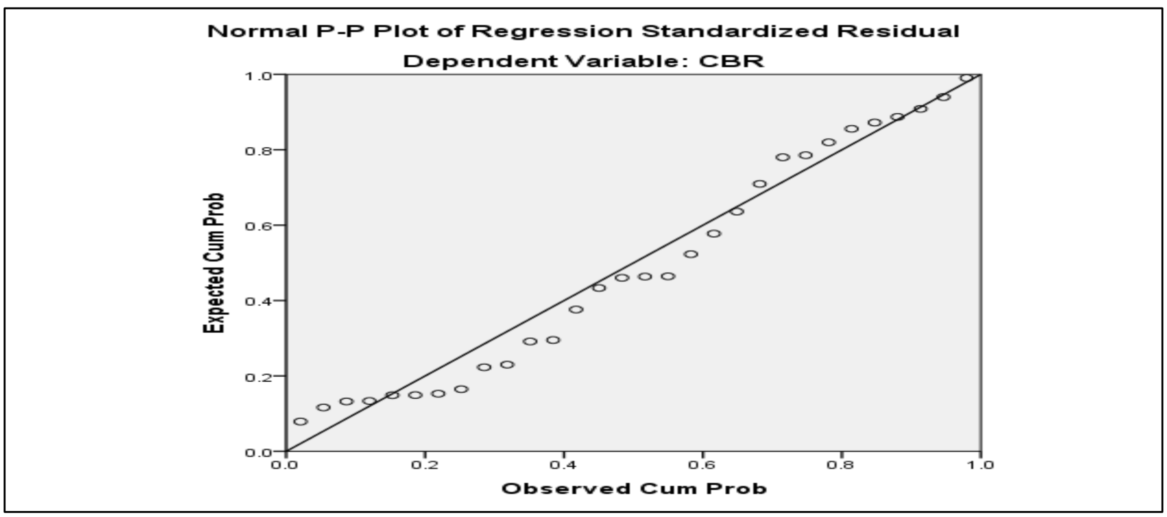
Coefficients[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	28.188	1.892		14.901	.000	24.313	32.064		
	OMC	-.670	.061	-.902	-11.063	.000	-.794	-.546	1.000	1.000

a. Dependent Variable: CBR

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.345	10.641	7.343	1.8958	30
Residual	-1.3031	2.1592	.0000	.9068	30
Std. Predicted Value	-1.582	1.739	.000	1.000	30
Std. Residual	-1.412	2.340	.000	.983	30

a. Dependent Variable: CBR





Appendix G

Single Regression Analysis Result between CBR and MDD

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	MDD[b]	.	Enter

a. Dependent Variable: CBR

b. All requested variables entered.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.894[a]	.799	.792	.9591	1.666

a. Predictors: (Constant), MDD

b. Dependent Variable: CBR

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	102.318	1	102.318	111.235	.000[b]
	Residual	25.755	28	.920		
	Total	128.074	29			

a. Dependent Variable: CBR

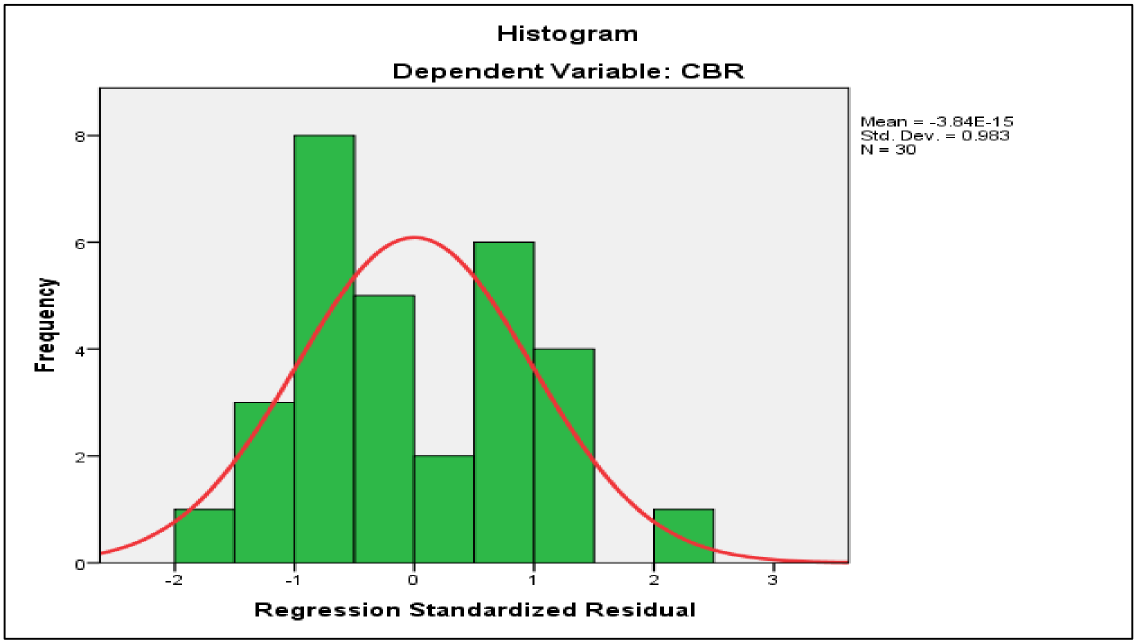
b. Predictors: (Constant), MDD

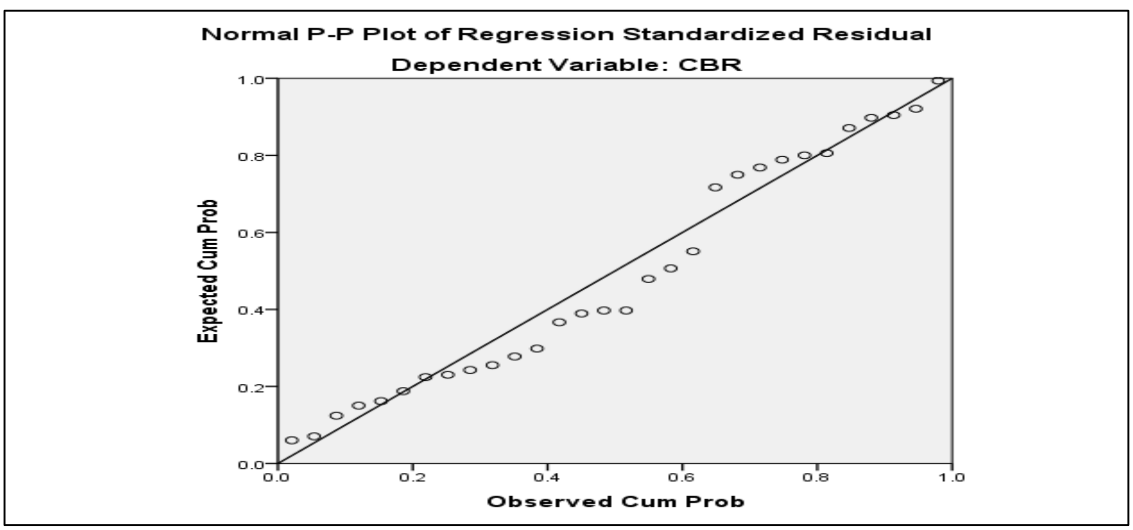
Coefficients[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-54.151	5.833		-9.283	.000	-66.100	-42.202		
	MDD	41.918	3.974	.894	10.547	.000	33.777	50.060	1.000	1.000

a. Dependent Variable: CBR

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.277	10.403	7.343	1.8784	30
Residual	-1.4883	2.3966	.0000	.9424	30
Std. Predicted Value	-2.165	1.629	.000	1.000	30
Std. Residual	-1.552	2.499	.000	.983	30

a. Dependent Variable: CBR





Appendix H

Multiple Regression Analysis Result for the best fit Model between CBR and LL, OMC and MDD (the bolded one)

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	LL[b]	.	Enter
2	OMC[b]	.	Enter
3	MDD[b]	.	Enter
4	PP200[b]	.	Enter

a. Dependent Variable: CBR
b. All requested variables entered.

Model Summary[e]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.846[a]	.716	.706	1.1394	
2	.927[b]	.859	.849	.8177	
3	**.948[c]**	**.899**	**.887**	**.7068**	
4	.929[d]	.863	.856	.7947	2.052

a. Predictors: (Constant), LL
b. Predictors: (Constant), LL, OMC
c. Predictors: (Constant), LL, OMC, MDD
d. Predictors: (Constant), LL, OMC, MDD, PP200
e. Dependent Variable: CBR

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	91.721	1	91.721	70.646	.000[b]
	Residual	36.353	28	1.298		
	Total	128.074	29			
2	Regression	110.019	2	55.010	74.431	.000[c]
	Residual	19.955	27	.0.739		
	Total	128.074	29			
3	**Regression**	**115.087**	**3**	**38.362**	**76.799**	**.000[d]**
	Residual	**12.987**	**26**	**.500**		
	Total	**128.074**	**29**			
4	Regression	115.097	4	28.774	55.442	.000[e]
	Residual	12.977	25	.519		
	Total	128.074	29			

a. Dependent Variable: CBR
b. Predictors: (Constant), LL
c. Predictors: (Constant), LL, OMC
d. Predictors: (Constant), LL, OMC, MDD
e. Predictors: (Constant), LL, OMC, MDD, PP200

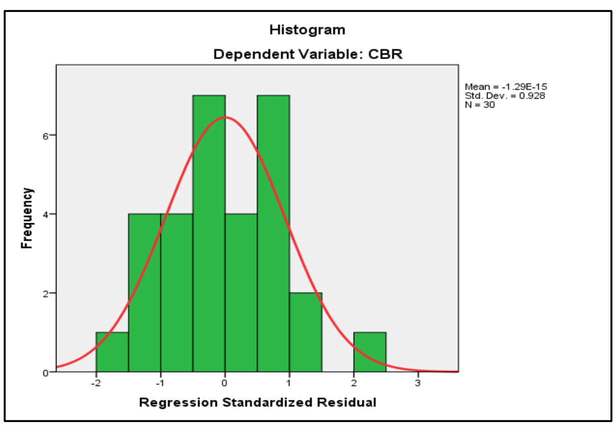
Coefficients[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	19.225	1.429		13.455	.000	16.298	22.152		
	LL	-.188	.022	-.846	-8.405	.000	-.234	-.142	1.000	1.000
2	(Constant)	26.669	1.754		15.205	.000	23.070	30.268		
	LL	-.078	.027	-.351	-2.943	.007	-.132	-.024	.368	2.719
	OMC	-.463	.088	-.623	-5.231	.000	-.644	-.281	.368	2.719
3	**(Constant)**	**-12.124**	**12.274**		**-.988**	**.332**	**-37.354**	**13.105**		
	LL	**-.077**	**.023**	**-.348**	**-3.380**	**.002**	**-.125**	**-.030**	**.368**	**2.719**
	OMC	**-.178**	**.118**	**-.239**	**-1.509**	**.032**	**-.420**	**.064**	**.155**	**6.447**
	MDD	**20.370**	**6.396**	**.434**	**3.185**	**.004**	**7.224**	**33.516**	**.210**	**4.768**
4	(Constant)	-7.196	12.580		-.572	.572	-33.104	18.713		
	LL	-.077	.023	-.346	-3.416	.002	-.123	-.031	.368	2.720
	OMC	-.130	.121	-.176	-1.081	.290	-.379	.118	.143	7.008
	MDD	19.508	6.317	.416	3.088	.005	6.498	32.518	.208	4.815
	PP200	-.063	.045	-.118	-1.383	.179	-.156	.031	.517	1.935

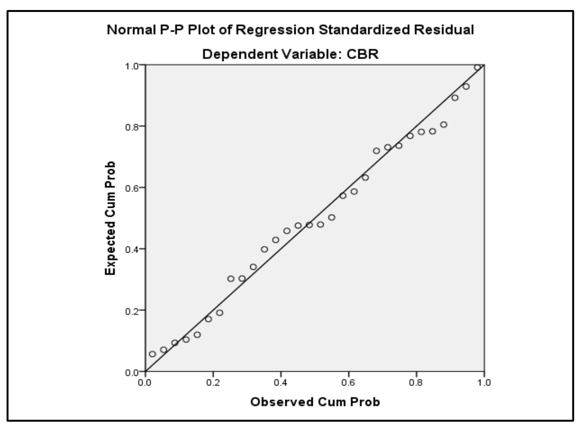
a. Dependent Variable: CBR

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.525	11.152	7.343	2.0001	30
Residual	-1.1009	1.6479	.0000	.6450	30
Std. Predicted Value	-1.909	1.904	.000	1.000	30
Std. Residual	-1.585	2.372	.000	.928	30

a. Dependent Variable: CBR





Appendix I: Typical Laboratory analysis test result of Natural Moisture Content

Test	Natural Moisture Content (ASTM D 2216-98a)						
Site	New Generation KG School				Test Pit	TP7 @ 1, 2 and 3m	
Determination of Natural Moisture Content							
	Unit						
Depth from NGL	m	1		2		3	
Specimen Trial		1	2	1	2	1	2
Can Code		HC12	O2-3	22	C2	3	P2
Weight of Can	gram	18.14	17.64	18.01	17.56	17.16	17.47
Weight of Can + Wet Soil	gram	89.27	81.36	70.23	77.66	76.23	79.77
Weight of Can + Dry Soil	gram	68.2	62.32	54.78	59.92	59.2	61.92
Moisture Content	%	42.09	42.61	42.02	41.88	40.51	40.16
Average Moisture Content	%	**42.4**		**41.9**		**40.3**	

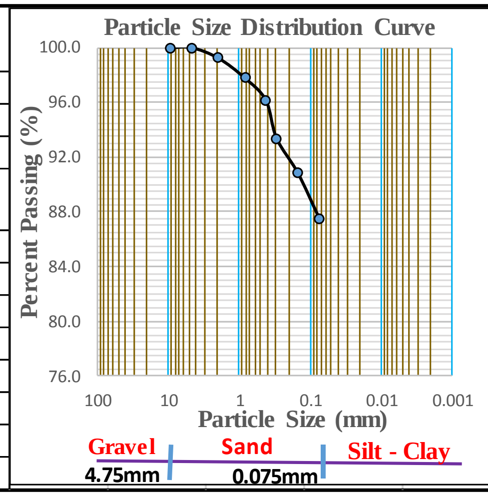
Appendix J: Typical Laboratory analysis test result of Specific Gravity

Test	**Specific Gravity (ASTM D 854-98)**									
Site	**New Generation KG School**					**Test Pit**		**7 @ 1, 2 and 3m**		
Determination of Specific Gravity (GS) of Soil										
Initial Temperature when MPW was taken,	22℃		Final Temperature when MPSW was taken, Tx					23℃		
	Unit									
Depth from NGL	m	1			2			3		
Trial no.		1	2	3	1	2	3	1	2	3
Pycnometer Code		1	2	3	4	5	6	7	8	9
Mass of Pycnometer(MP)	gram	31.94	30.18	31.36	30.85	28.79	29.96	31.53	30.91	31.74
Mass of Pycnometer + Water (MPW) at Ti	gram	126.8	122.9	126.2	126.4	125	123.31	126.6	128.2	126.4
Mass of dry soil + Pycnometer (MPS)	gram	41.85	40.89	41.1	41.17	39.21	39.808	41.29	40.9	41.71
Mass of dry soil	gram	9.911	10.71	9.738	10.31	10.42	9.848	9.766	9.992	9.967
Mass of Pycnometer +Soil + Water (MPSW)	gram	133	129.6	132.3	132.9	131.5	129.485	132.7	134.5	132.7
Temp. of Contents of Pycnometer when MPSW was taken,Tx	℃	23	23	23	23	23	23	23	23	23
Correction factor (K) for Tx		0.999	0.999	0.999	0.999	0.999	0.9993	0.999	0.999	0.999
Specific Gravity at Tx		2.70	2.71	2.68	2.68	2.67	2.68	2.66	2.67	2.67
Specific Gravity at 20℃		2.70	2.71	2.68	2.68	2.67	2.68	2.66	2.66	2.66
Average Specific Gravity at 20℃		**2.70**			**2.68**			**2.66**		

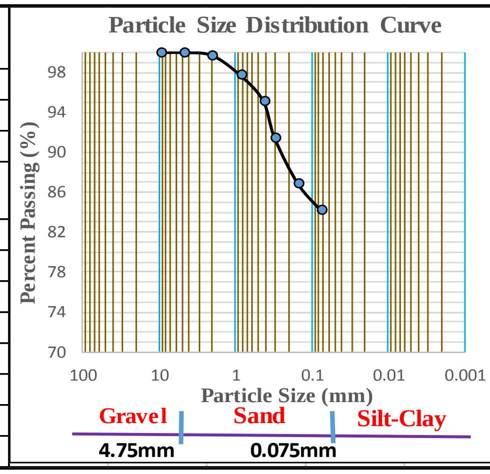
Appendix K

Grain Size Distribution (Wet Sieve) Laboratory Analysis and Test result of all Samples

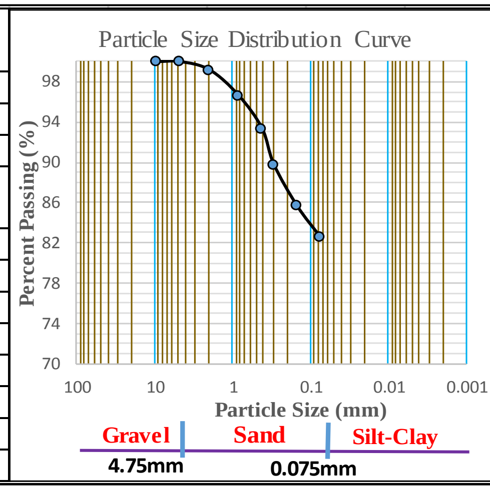
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Agricultural Office			Test Pit	1 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	MassRetained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100.0
#4	4.75	0	0	0	100.0
#10	2	3.8	0.76	0.76	99.2
#20	0.85	7.2	1.44	2.2	97.8
#40	0.425	8.2	1.64	3.84	96.2
#50	0.3	13.9	2.78	6.62	93.4
#100	0.15	12.7	2.54	9.16	90.8
#200	0.075	16.5	3.3	12.46	**87.5**



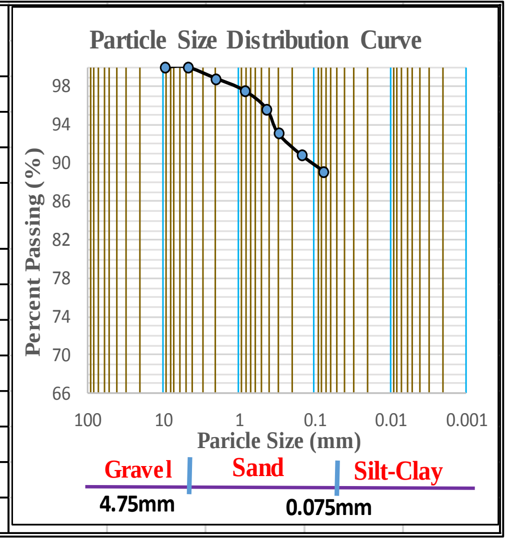
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Agricultural Office			Test Pit	1 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	1.4	0.28	0.28	99.7
#20	0.85	9.9	1.98	2.26	97.7
#40	0.425	12.8	2.56	4.82	95.2
#50	0.3	18.7	3.74	8.56	91.4
#100	0.15	22.6	4.52	13.08	86.9
#200	0.075	13.5	2.7	15.78	84.2



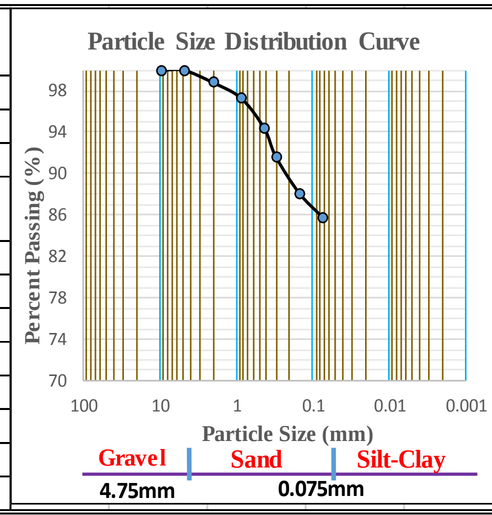
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Agricultural Office			Test Pit	1 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	4.1	0.82	0.82	99.18
#20	0.85	12.6	2.52	3.34	96.7
#40	0.425	16.3	3.26	6.6	93.4
#50	0.3	17.8	3.56	10.16	89.84
#100	0.15	20.7	4.14	14.3	85.7
#200	0.075	15.5	3.1	17.4	82.6



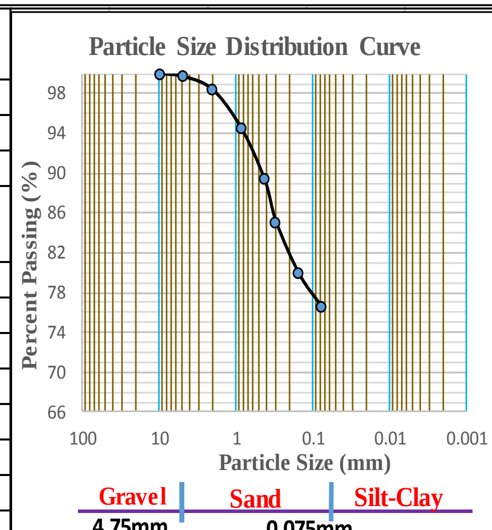
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Town Bus Station			Test Pit	2 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	5.8	1.16	1.16	98.84
#20	0.85	6.2	1.24	2.4	97.6
#40	0.425	9.6	1.92	4.32	95.68
#50	0.3	12.7	2.54	6.86	93.1
#100	0.15	11.2	2.24	9.1	90.9
#200	0.075	8.7	1.74	10.84	89.2



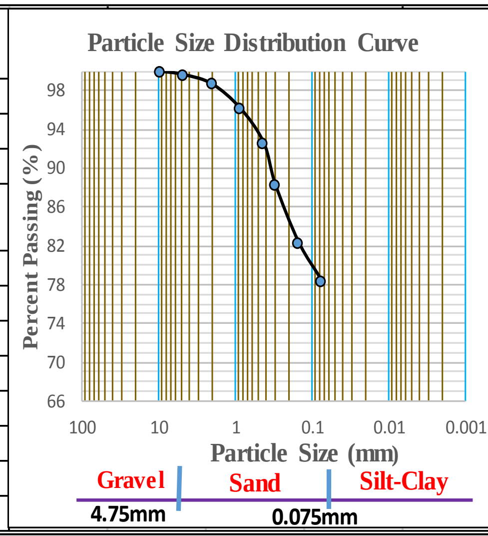
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Town Bus Station			Test Pit	2 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	5.9	1.18	1.18	98.8
#20	0.85	7.7	1.54	2.72	97.3
#40	0.425	14.6	2.92	5.64	94.4
#50	0.3	13.8	2.76	8.4	91.6
#100	0.15	17.5	3.5	11.9	88.1
#200	0.075	11.7	2.34	14.24	85.8



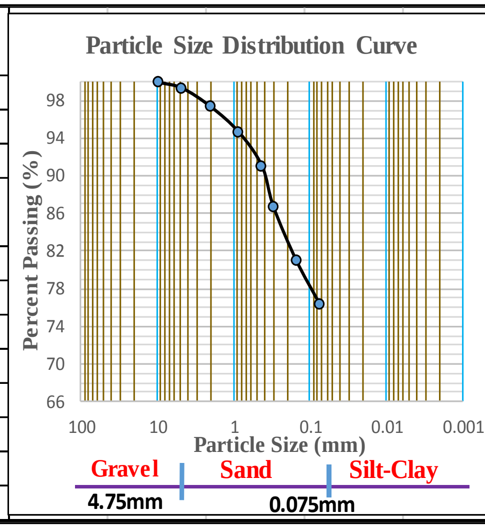
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Town Bus Station			Test Pit	2 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	1.5	0.3	0.3	99.7
#10	2	6.7	1.34	1.64	98.4
#20	0.85	19.4	3.88	5.52	94.5
#40	0.425	25.6	5.12	10.64	89.4
#50	0.3	21.3	4.26	14.9	85.1
#100	0.15	26.1	5.22	20.12	79.9
#200	0.075	16.7	3.34	23.46	76.5



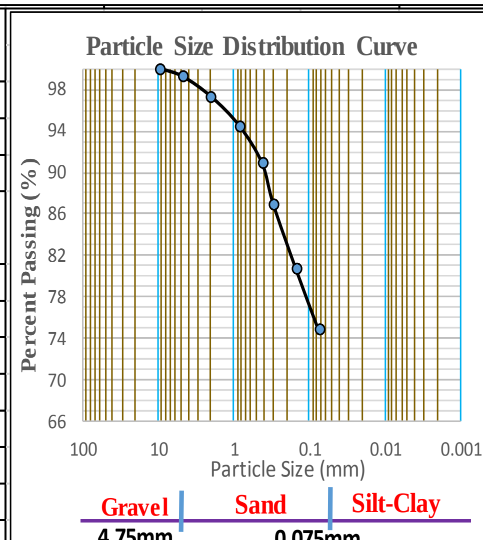
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Police Office			Test Pit	3 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	1.7	0.34	0.34	99.66
#10	2	4.8	0.96	1.3	98.7
#20	0.85	12.7	2.54	3.84	96.2
#40	0.425	17.7	3.54	7.38	92.6
#50	0.3	21.6	4.32	11.7	88.3
#100	0.15	29.8	5.96	17.66	82
#200	0.075	19.9	3.98	21.64	78.4



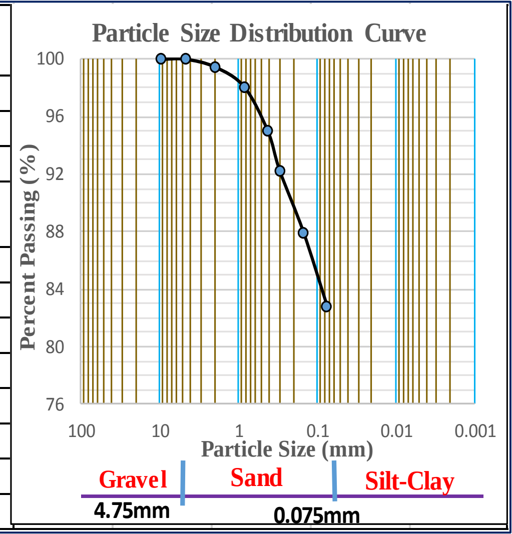
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Police Office			Test Pit	3 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	3.1	0.62	0.62	99.38
#10	2	9.9	1.98	2.6	97.4
#20	0.85	13.7	2.74	5.34	94.7
#40	0.425	17.9	3.58	8.92	91.1
#50	0.3	21.8	4.36	13.28	86.7
#100	0.15	28.7	5.74	19.02	81.0
#200	0.075	22.8	4.56	23.58	76.4



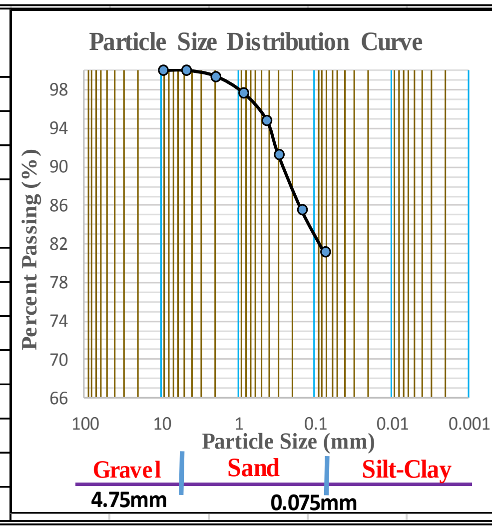
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Police Office			Test Pit	3 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	3.9	0.78	0.78	99.22
#10	2	9.7	1.94	2.72	97.3
#20	0.85	13.9	2.78	5.5	94.5
#40	0.425	17.8	3.56	9.06	90.9
#50	0.3	19.9	3.98	13.04	87.0
#100	0.15	31.2	6.24	19.28	80.7
#200	0.075	29.4	5.88	25.16	74.8



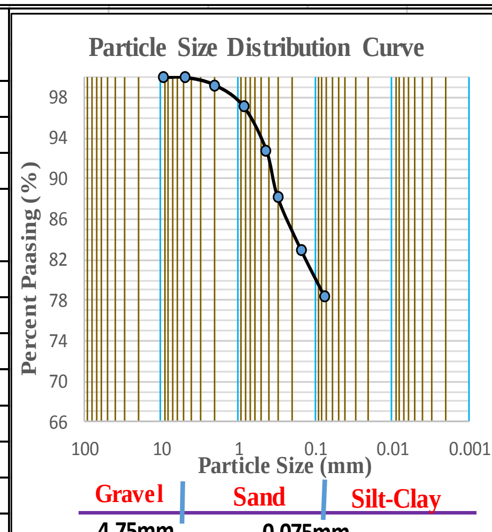
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Administration Office			Test Pit	4 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.7	0.54	0.54	99.46
#20	0.85	6.9	1.38	1.92	98.08
#40	0.425	15.4	3.08	5	95.0
#50	0.3	13.8	2.76	7.76	92.2
#100	0.15	21.3	4.26	12.02	87.98
#200	0.075	25.7	5.14	17.16	82.8



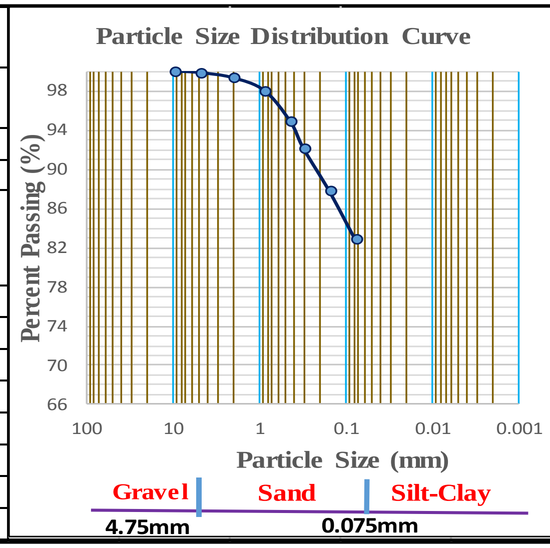
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Administration Office			Test Pit	4 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.9	0.58	0.58	99.4
#20	0.85	8.8	1.76	2.34	97.7
#40	0.425	13.9	2.78	5.12	94.9
#50	0.3	17.8	3.56	8.68	91.3
#100	0.15	28.5	5.7	14.38	85.62
#200	0.075	22.4	4.48	18.86	81.1



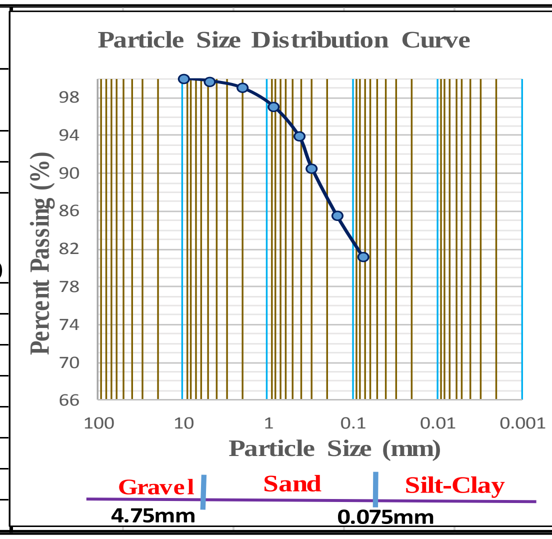
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Administration Office			Test Pit	4 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram (g)					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum.Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	3.7	0.74	0.74	99.3
#20	0.85	10.3	2.06	2.8	97.2
#40	0.425	21.7	4.34	7.14	92.9
#50	0.3	23.6	4.72	11.86	88.14
#100	0.15	25.8	5.16	17.02	83.0
#200	0.075	22.7	4.54	21.56	78.4



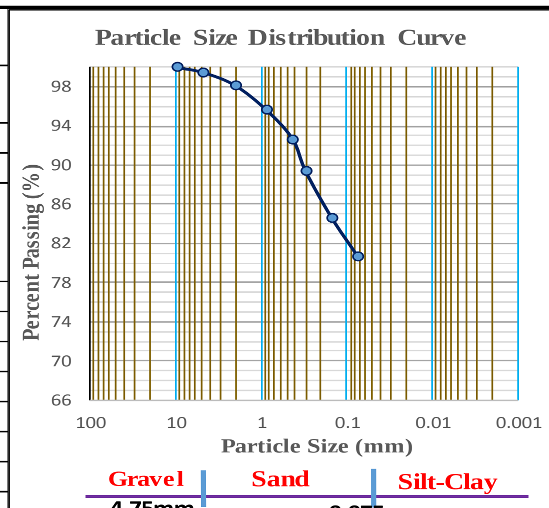
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Town Municipality Office			Test Pit	5 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass Retained (%)	Percentage Retained (%)	Cum. Percentage Retained (%)	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0.8	0.16	0.16	99.84
#10	2	2.5	0.5	0.66	99.34
#20	0.85	6.6	1.32	1.98	98.0
#40	0.425	15.8	3.16	5.14	94.9
#50	0.3	13.6	2.72	7.86	92.1
#100	0.15	21.8	4.36	12.22	87.8
#200	0.075	24.7	4.94	17.16	82.8



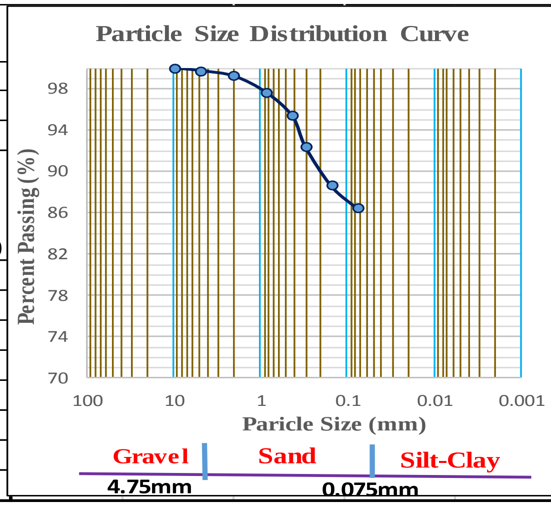
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Town Municipality Office			Test Pit	5 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative % retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	1.3	0.26	0.26	99.74
#10	2	3.6	0.72	0.98	99.0
#20	0.85	9.8	1.96	2.94	97.1
#40	0.425	15.7	3.14	6.08	93.9
#50	0.3	16.8	3.36	9.44	90.6
#100	0.15	25.5	5.1	14.54	85.5
#200	0.075	21.4	4.28	18.82	81.2



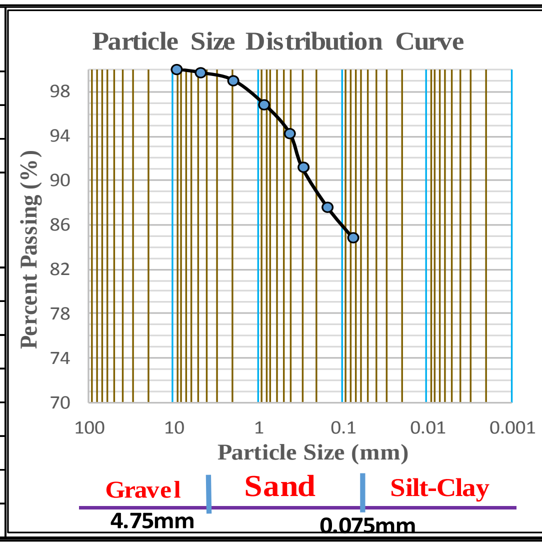
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Town Municipality Office			Test Pit	5 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative % retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	2.5	0.5	0.5	99.5
#10	2	6.6	1.32	1.82	98.2
#20	0.85	12.8	2.56	4.38	95.6
#40	0.425	14.7	2.94	7.32	92.7
#50	0.3	16.4	3.28	10.6	89.4
#100	0.15	23.7	4.74	15.34	84.7
#200	0.075	19.6	3.92	19.26	80.7



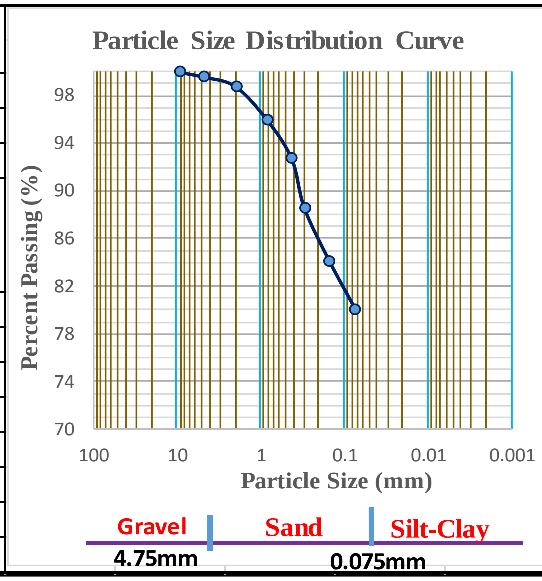
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka High School		Test Pit	6 @ 1m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram				500	
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative %retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	1.3	0.26	0.26	99.74
#10	2	2.6	0.52	0.78	99.22
#20	0.85	7.9	1.58	2.36	97.6
#40	0.425	11.5	2.3	4.66	95.3
#50	0.3	14.8	2.96	7.62	92.4
#100	0.15	18.9	3.78	11.4	88.6
#200	0.075	10.8	2.16	13.56	86.4



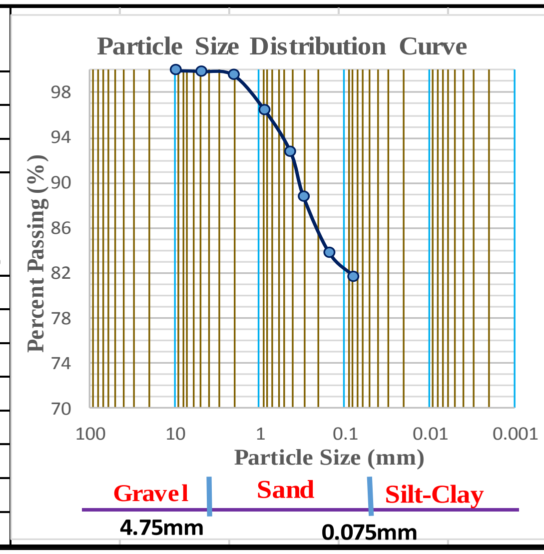
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka High School		Test Pit	6 @ 2m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram				500	
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative %retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	1.7	0.34	0.34	99.66
#10	2	3.2	0.64	0.98	99.0
#20	0.85	10.8	2.16	3.14	96.9
#40	0.425	12.9	2.58	5.72	94.3
#50	0.3	15.7	3.14	8.86	91.1
#100	0.15	17.9	3.58	12.44	87.56
#200	0.075	13.8	2.76	15.2	84.8



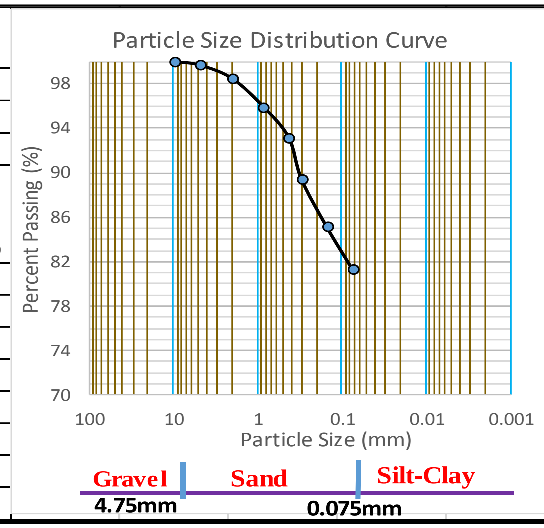
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka High School		Test Pit	6 @ 3m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram				500	
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative %retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	2.1	0.42	0.42	99.58
#10	2	3.9	0.78	1.2	98.8
#20	0.85	13.8	2.76	3.96	96.0
#40	0.425	16.7	3.34	7.3	92.7
#50	0.3	20.8	4.16	11.46	88.5
#100	0.15	22.5	4.5	15.96	84.0
#200	0.075	19.7	3.94	19.9	80.1



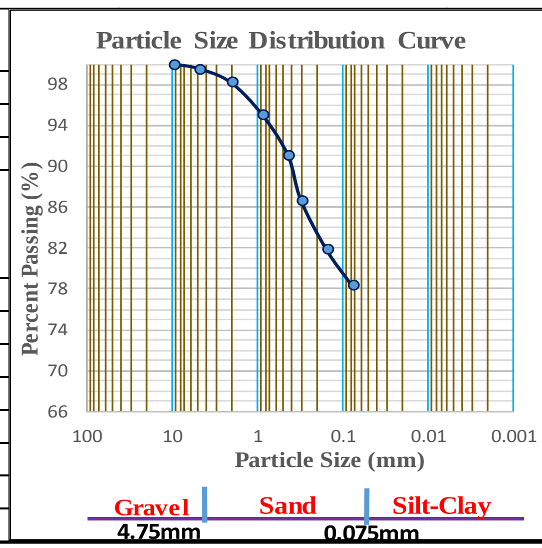
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	New Generation KG School		Test Pit		7 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve no.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative % retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0.4	0.08	0.08	99.92
#10	2	1.6	0.32	0.4	99.60
#20	0.85	15.8	3.16	3.56	96.4
#40	0.425	18.5	3.7	7.26	92.7
#50	0.3	19.9	3.98	11.24	88.8
#100	0.15	24.7	4.94	16.18	84
#200	0.075	10.7	2.14	18.32	81.7



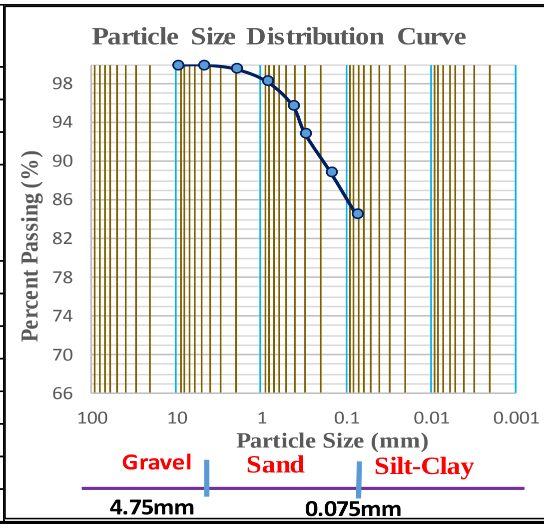
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	New Generation KG School		Test Pit		7 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cum.% retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	1.8	0.36	0.36	99.64
#10	2	5.9	1.18	1.54	98.5
#20	0.85	12.7	2.54	4.08	95.9
#40	0.425	13.8	2.76	6.84	93.2
#50	0.3	18.7	3.74	10.58	89.4
#100	0.15	21.5	4.3	14.88	85.1
#200	0.075	18.8	3.76	18.64	81.4



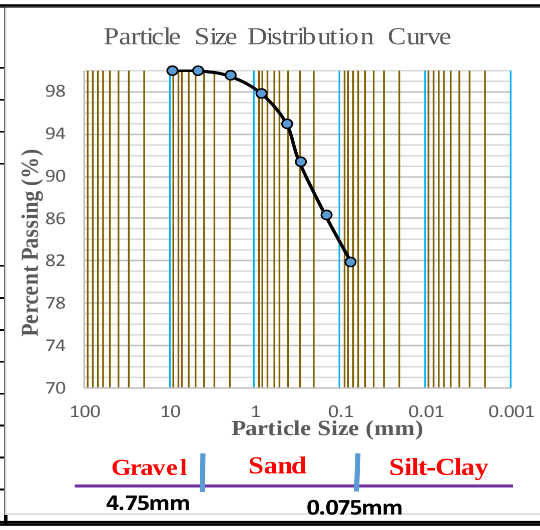
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	New Generation KG School		Test Pit		7 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil (g)	Percentge retained (%)	Cum. % retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	2.3	0.46	0.46	99.54
#10	2	6.7	1.34	1.8	98.2
#20	0.85	15.9	3.18	4.98	95.0
#40	0.425	19.8	3.96	8.94	91.1
#50	0.3	21.8	4.36	13.3	86.7
#100	0.15	24.3	4.86	18.16	81.8
#200	0.075	17.7	3.54	21.7	78.3



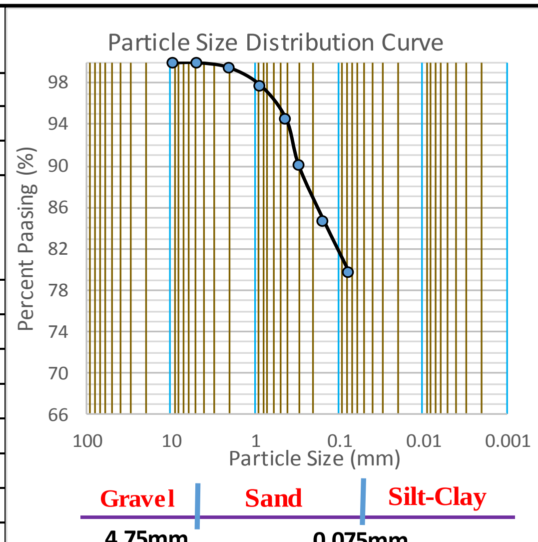
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Hospital		Test Pit	8 @ 1m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentge retained (%)	Cum.% retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.1	0.42	0.42	99.58
#20	0.85	6.5	1.3	1.72	98.3
#40	0.425	12.2	2.44	4.16	95.8
#50	0.3	14.8	2.96	7.12	92.9
#100	0.15	19.9	3.98	11.1	88.9
#200	0.075	21.7	4.34	15.44	84.6



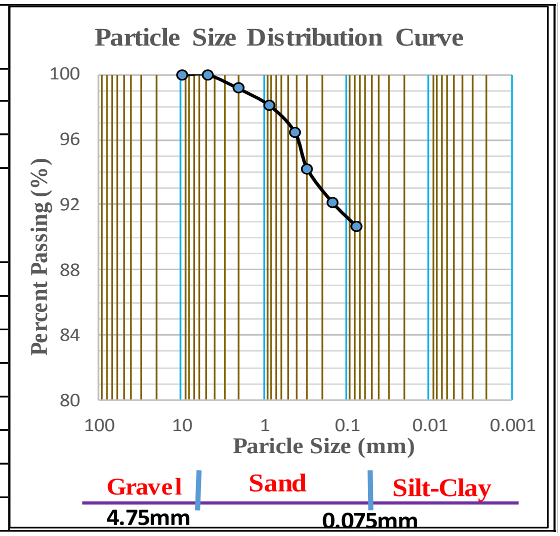
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Hospital		Test Pit	8 @ 2m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve no.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative %retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.4	0.48	0.48	99.5
#20	0.85	8.1	1.62	2.1	97.9
#40	0.425	14.3	2.86	4.96	95.0
#50	0.3	18.2	3.64	8.6	91.4
#100	0.15	25.1	5.02	13.62	86.4
#200	0.075	22.4	4.48	18.1	81.9



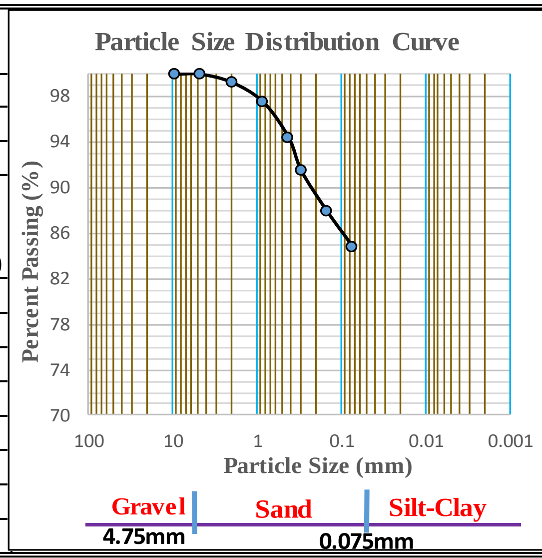
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Hospital		Test Pit	8 @ 3m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Sample before washing in gram					500
Sieve Number (N)	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cumulative %retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.4	0.48	0.48	99.5
#20	0.85	8.6	1.72	2.2	97.8
#40	0.425	16.1	3.22	5.42	94.6
#50	0.3	22.6	4.52	9.94	90.1
#100	0.15	26.8	5.36	15.3	84.7
#200	0.075	24.9	4.98	20.28	79.7



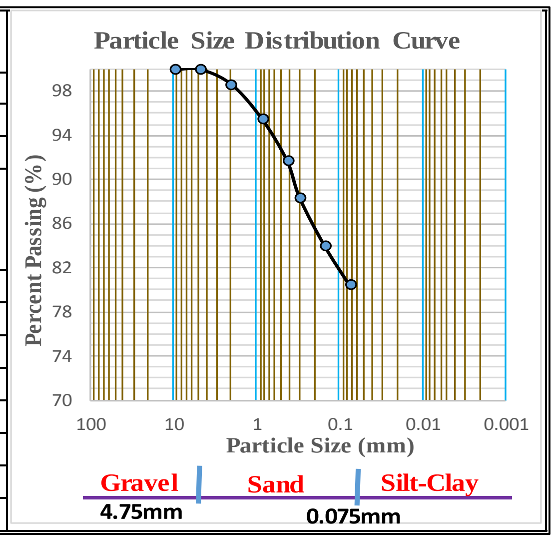
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Preparatory School		Test Pit	9 @ 1m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cum.%retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	4.3	0.86	0.86	99.14
#20	0.85	5.2	1.04	1.9	98.1
#40	0.425	8.1	1.62	3.52	96.48
#50	0.3	11.3	2.26	5.78	94.2
#100	0.15	10.2	2.04	7.82	92.2
#200	0.075	7.6	1.52	9.34	90.7



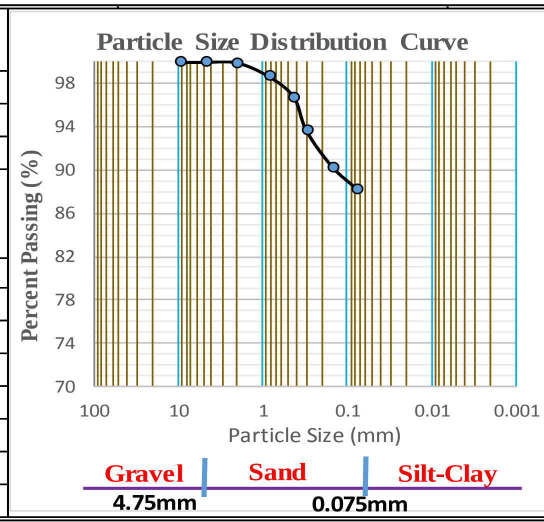
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Preparatory School		Test Pit	9 @ 2m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cum.% retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	3.6	0.72	0.72	99.28
#20	0.85	8.7	1.74	2.46	97.5
#40	0.425	15.6	3.12	5.58	94.4
#50	0.3	14.7	2.94	8.52	91.5
#100	0.15	17.6	3.52	12.04	87.96
#200	0.075	15.4	3.08	15.12	84.9



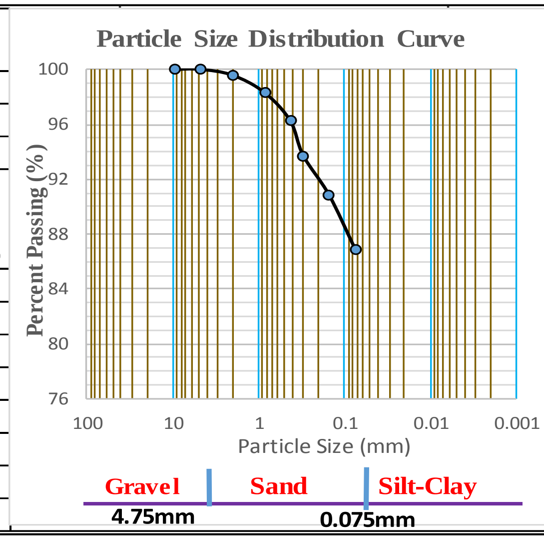
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Seka Preparatory School		Test Pit	9 @ 3m	
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cum.%retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	6.8	1.36	1.36	98.64
#20	0.85	15.8	3.16	4.52	95.5
#40	0.425	18.9	3.78	8.3	91.7
#50	0.3	16.7	3.34	11.64	88.4
#100	0.15	21.8	4.36	16	84.0
#200	0.075	17.9	3.58	19.58	80.4



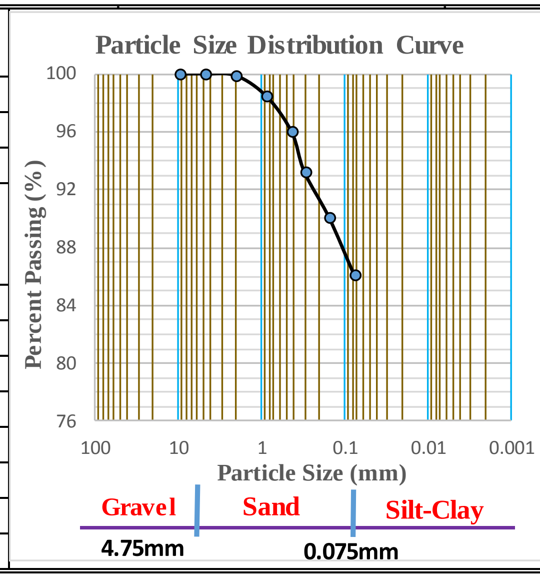
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Lideta Orthodox Church			Test Pit	10 @ 1m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	Percentage retained (%)	Cum.%retained	Percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	0.2	0.04	0.04	99.96
#20	0.85	6.2	1.24	1.28	98.7
#40	0.425	9.6	1.92	3.2	96.8
#50	0.3	15.7	3.14	6.34	93.7
#100	0.15	16.6	3.32	9.66	90
#200	0.075	10.7	2.14	11.8	88.2



Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Lideta Orthodox Church			Test Pit	10 @ 2m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil (g)	percentage retained (%)	Cum.% retained	percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.1	0.42	0.42	99.58
#20	0.85	6.3	1.26	1.68	98.3
#40	0.425	10.3	2.06	3.74	96.3
#50	0.3	12.7	2.54	6.28	93.7
#100	0.15	14.4	2.88	9.16	90.8
#200	0.075	19.6	3.92	13.08	86.9



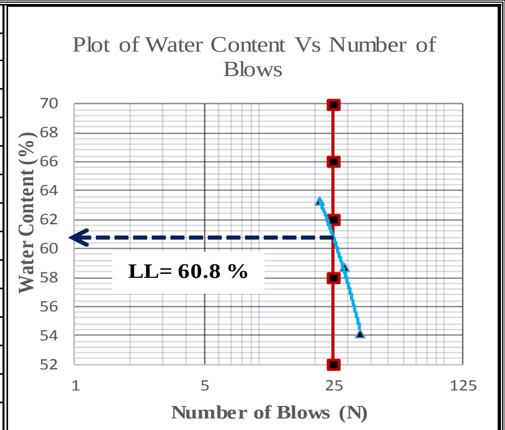
Test	Grain Size Distribution Analysis (Wet Sieve Analysis)				
Site	Lideta Orthodox Church			Test Pit	10 @ 3m
Determination of Wet Sieve Analysis of Soil					
Dry Weight of soil Sample before washing in gram					500
Sieve No.	Sieve size (mm)	Mass of retained soil(g)	ercentage retained (%)	Cum. %retained	percentage Passing (%)
3/8"	9.5	0	0	0	100
#4	4.75	0	0	0	100
#10	2	2.3	0.13	0.13	99.9
#20	0.85	7.3	1.46	1.59	98.4
#40	0.425	12.3	2.46	4.05	96.0
#50	0.3	13.7	2.74	6.79	93.2
#100	0.15	15.9	3.18	9.97	90.0
#200	0.075	19.7	3.94	13.91	86.1



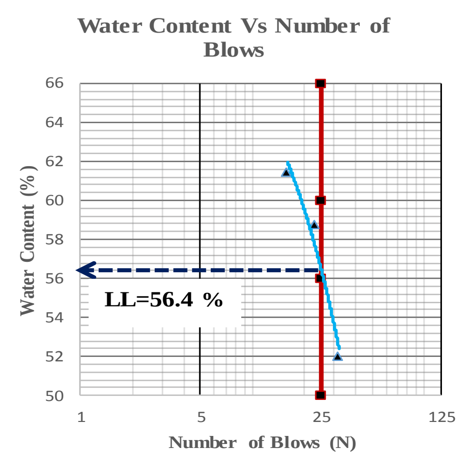
Appendix L

Atterberg's Limits Laboratory Analysis and test result of all Samples

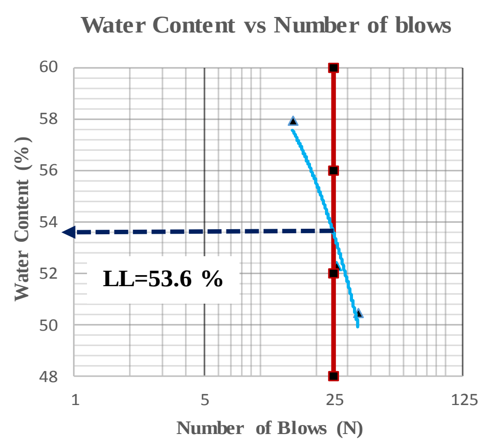
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Agricultural Office			Test Pit		1 @ 1m
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**PlasticLimit**	
Trial number		1	2	3	1	2
Number of Blows	N	35	29	21		
Can Code		G	G53	NB	3A	G3T2
Mass of empty Can (MC)	gram	17.7	17.02	17.3	17.6	17.9
M of Can +Wet Soil (McWs)	gram	32.7	31.29	31	24.1	23.94
M of Can + Dry Soil (McDs)	gram	27.5	26.01	25.7	22.5	22.46
Mass of Dry soil (MDs)	gram	9.73	8.99	8.4	4.89	4.56
Mass of Water (Mw)	gram	5.27	5.28	5.32	1.59	1.48
Water Content (w)	%	54.16	58.73	63.27	32.46	32.46
Liquid Limit (LL)	**%**	**60.8**				
Plastic Limit (PL)	**%**	**32.5**				
PLastic Index (PI)	**%**	**28.3**				



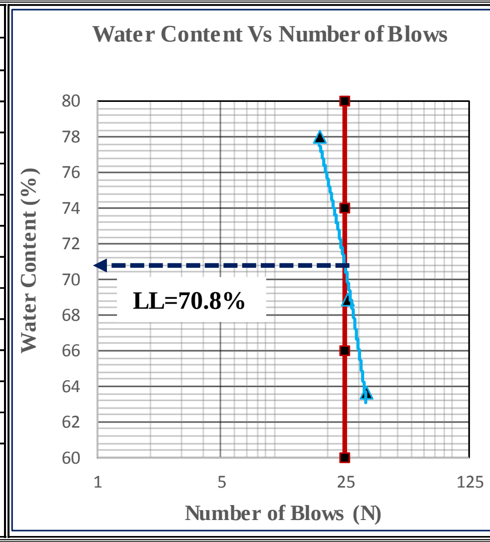
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Agricultural Office			Test Pit		1 @2m
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	23	16		
Can Code		G3T2	P5	T2C1	50	G
Mass of empty Can (MC)	gram	17.1	17.16	17	17.9	18.01
Mass of Can + Wet Soil (McWs)	gram	34.7	35.71	34.2	25.4	25.43
Mass of Can + Dry Soil (McDs)	gram	28.7	28.84	27.7	23.6	23.716
Mass of Dry soil (MDs)	gram	11.5	11.68	10.6	5.7	5.706
Mass of Water (Mw)	gram	6.00	6.87	6.54	1.73	1.71
Water Content (w)	%	51.98	58.80	61.43	30.36	30.04
Liquid Limit (LL)	**%**	**56.4**				
Plastic Limit (PL)	**%**	**30.2**				
PLastic Index (PI)	**%**	**26.2**				



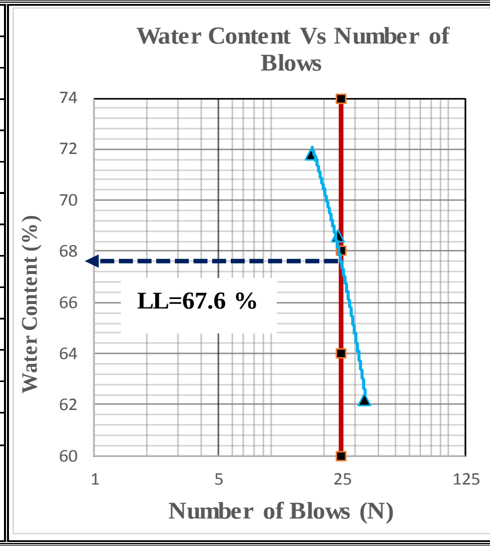
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Agricultural Office			Test Pit		1 @ 3m
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	26	15		
Can Code		A2	30	C2	G2	20
Mass of empty Can (MC)	gram	8.16	7.895	6.2	17.3	17.03
Mass of Can + Wet Soil (McWs)	gram	21.1	20.59	20.4	23.9	23.96
Mass of Can + Dry Soil (McDs)	gram	16.7	16.23	15.2	22.4	22.37
Mass of Dry soil (MDs)	gram	8.57	8.335	8.98	5.04	5.34
Mass of Water (Mw)	gram	4.33	4.36	5.21	1.5	1.59
Water Content (w)	%	50.45	52.31	57.95	29.76	29.78
Liquid Limit (LL)	%	**53.6**				
Plastic Limit (PL)	%	**29.8**				
PLastic Index (PI)	%	**23.8**				



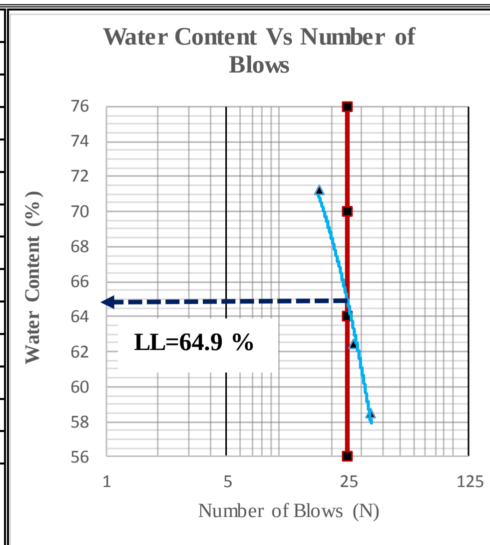
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Town Bus Station			Test Pit	2 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	33	26	18		
Can Code		P2	A3	G3T3	B3	T1C1
Mass of empty Can (MC)	gram	17.19	16.99	17.9	17.4	17.717
Mass of Can + Wet Soil (McWs)	gram	31.1	30.83	32.98	24.6	24.703
Mass of Can + Dry Soil (McDs)	gram	25.69	25.19	26.37	22.68	22.835
Mass of Dry soil (MDs)	gram	8.5	8.199	8.468	5.28	5.118
Mass of Water (Mw)	gram	5.41	5.64	6.61	1.921	1.87
Water Content (w)	%	63.65	68.84	78.06	36.38	36.50
Liquid Limit (LL)	%	**70.8**				
Plastic Limit (PL)	%	**36.4**				
PLastic Index (PI)	%	**34.4**				



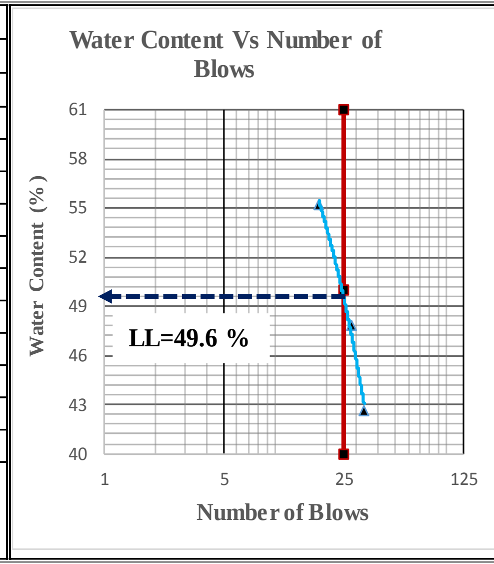
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Town Bus Station			Test Pit	2 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	24	17		
Can Code		P2	A3	B3	P1	4
Mass of empty Can (MC)	gram	18.4	17.38	17.4	17.9	17.56
Mass of Can + Wet Soil (McWs)	gram	32	30.2	32.4	24.3	24.08
Mass of Can + Dry Soil (McDs)	gram	26.8	24.98	26.1	22.5	22.27
Mass of Dry soil (MDs)	gram	8.37	7.601	8.71	4.61	4.71
Mass of Water (Mw)	gram	5.20	5.22	6.25	1.77	1.81
Water Content (w)	%	62.20	68.62	71.80	38.35	38.43
Liquid Limit (LL)	%	**67.6**				
Plastic Limit (PL)	%	**38.4**				
PLastic Index (PI)	%	**29.2**				



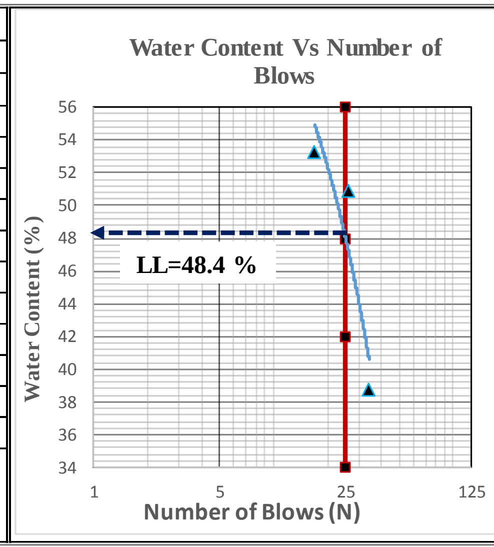
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Town Bus Station			Test Pit	2 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	27	17		
Can Code		37	12	58	49	29
Mass of empty Can (MC)	gram	5.98	6.558	6.34	5.53	6.045
Mass of Can + Wet Soil (McWs)	gram	22	22.51	22.3	11.9	13.35
Mass of Can + Dry Soil (McDs)	gram	16.1	16.38	15.6	10.2	11.4
Mass of Dry soil (MDs)	gram	10.1	9.822	9.29	4.7	5.355
Mass of Water (Mw)	gram	5.91	6.13	6.62	1.71	1.95
Water Content (w)	%	58.48	62.41	71.26	36.46	36.41
Liquid Limit (LL)	%	**64.9**				
Plastic Limit (PL)	%	**36.4**				
PLastic Index (PI)	%	**28.5**				



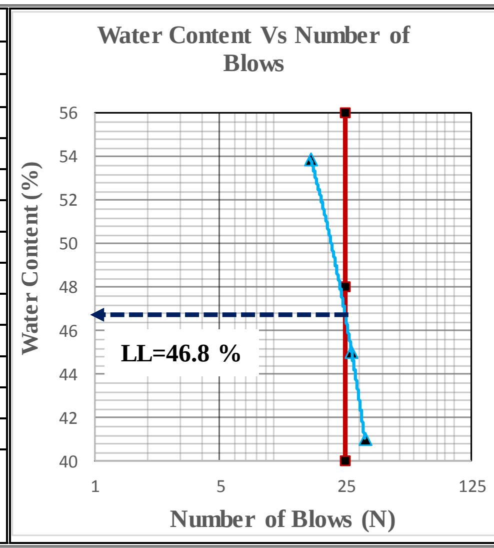
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Police Office		Test Pit		3 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	33	28	18		
Can Code		31	C4	27	3	C12
Mass of empty Can (MC)	gram	8.249	17.69	5.85	16.59	16.32
Mass of Can + Wet Soil (McWs)	gram	22.42	33.05	23.22	22.62	23.201
Mass of Can + Dry Soil (McDs)	gram	18.18	28.08	17.04	21.24	21.61
Mass of Dry soil (MDs)	gram	9.931	10.39	11.19	4.645	5.29
Mass of Water (Mw)	gram	4.24	4.97	6.18	1.385	1.59
Water Content (w)	%	42.64	47.83	55.19	29.82	30.08
Liquid Limit (LL)	%	**49.6**				
Plastic Limit (PL)	%	**29.9**				
PLastic Index (PI)	%	**19.7**				



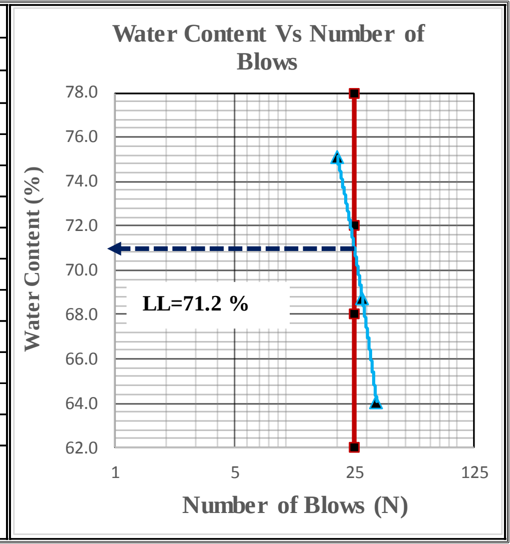
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Police Office		Test Pit		3 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	26	17		
Can Code		2	MK	3	6	G7
Mass of empty Can (MC)	gram	17.64	17.72	18.22	17.05	17.387
Mass of Can + Wet Soil (McWs)	gram	30.66	28.69	32.25	23.25	23.581
Mass of Can + Dry Soil (McDs)	gram	27.02	24.99	27.37	21.82	22.16
Mass of Dry soil (MDs)	gram	9.384	7.274	9.152	4.771	4.773
Mass of Water (Mw)	gram	3.64	3.70	4.87	1.426	1.42
Water Content (w)	%	38.78	50.89	53.26	29.89	29.77
Liquid Limit (LL)	%	**48.4**				
Plastic Limit (PL)	%	**29.8**				
PLastic Index (PI)	%	**18.6**				



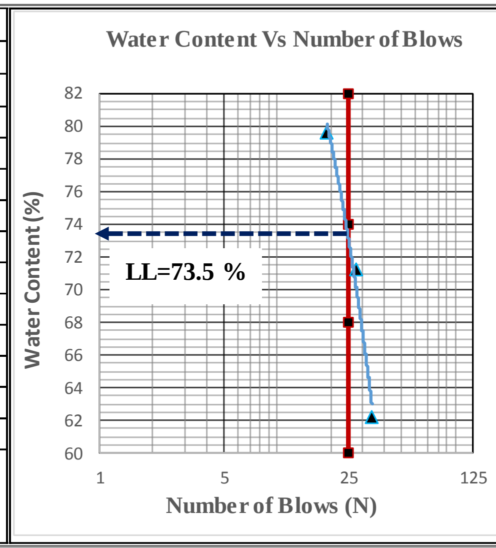
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Police Office		Test Pit		3 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	27	16		
Can Code		B1	G7	3	G3T3	HC11
Mass of empty Can (MC)	gram	18.23	18.49	17.72	17.56	17.683
Mass of Can + Wet Soil (McWs)	gram	35.1	34.43	32.14	26.3	25.32
Mass of Can + Dry Soil (McDs)	gram	30.19	29.48	27.09	24.4	23.65
Mass of Dry soil (MDs)	gram	11.96	10.99	9.367	6.837	5.967
Mass of Water (Mw)	gram	4.91	4.95	5.05	1.901	1.67
Water Content (w)	%	41.06	45.05	53.91	27.80	27.99
Liquid Limit (LL)	%	**46.8**				
Plastic Limit (PL)	%	**27.9**				
PLastic Index (PI)	%	**18.9**				



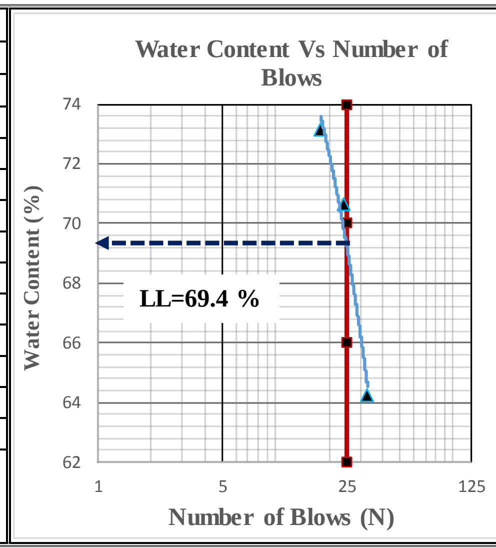
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)						
Site	Administration Office			Test Pit		4 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index							
	Units						
Test		Liquid Limit			Plastic Limit		
Trial number		1	2	3	1	2	
Number of Blows	N	34	28	20			
Can Code		C2	A2	3	60	38	
Mass of empty Can (MC)	gram	6.26	6.052	16.6	6.455	6.175	
Mass of Can + Wet Soil (McWs)	gram	17.81	17.47	27.65	15.87	15.22	
Mass of Can + Dry Soil (McDs)	gram	13.3	12.82	22.91	12.97	12.426	
Mass of Dry soil (MDs)	gram	7.04	6.767	6.31	6.514	6.251	
Mass of Water (Mw)	gram	4.51	4.65	4.74	2.901	2.79	
Water Content (w)	%	64.06	68.75	75.12	44.53	44.70	
Liquid Limit (LL)	%	**71.2**					
Plastic Limit (PL)	%	**44.6**					
PLastic Index (PI)	%	**26.6**					



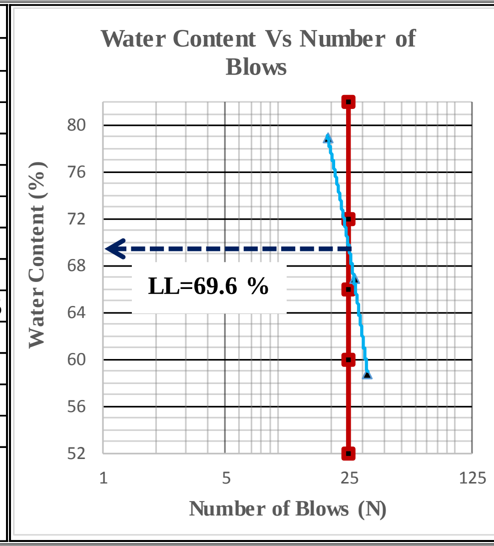
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)						
Site	Administration Office			Test Pit		4 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index							
	Units						
Test		Liquid Limit			Plastic Limit		
Trial number		1	2	3	1	2	
Number of Blows	N	34	28	19			
Can Code		R1	A20	13	56	60	
Mass of empty Can (MC)	gram	6.52	19.66	6.711	6.399	6.409	
Mass of Can + Wet Soil (McWs)	gram	18.54	31.05	18.99	12.49	12.77	
Mass of Can + Dry Soil (McDs)	gram	13.93	26.31	13.55	10.62	10.815	
Mass of Dry soil (MDs)	gram	7.41	6.65	6.836	4.221	4.406	
Mass of Water (Mw)	gram	4.61	4.74	5.44	1.87	1.96	
Water Content (w)	%	62.17	71.28	79.62	44.30	44.37	
Liquid Limit (LL)	%	**73.5**					
Plastic Limit (PL)	%	**44.3**					
PLastic Index (PI)	%	**29.2**					



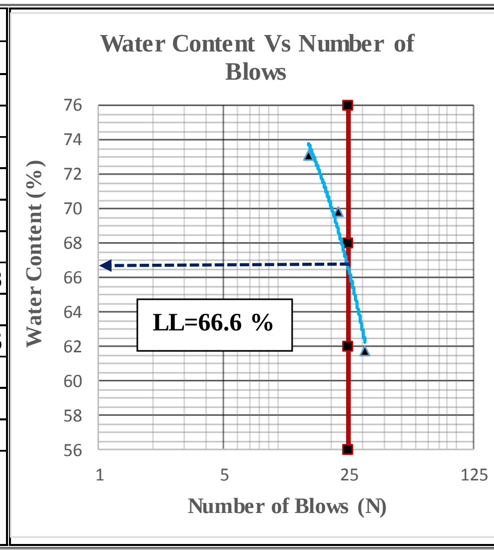
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)						
Site	Administration Office			Test Pit		4 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index							
	Units						
Test		Liquid Limit			Plastic Limit		
Trial number		1	2	3	1	2	
Number of Blows	N	33	24	18			
Can Code		A20	38	56	13	49	
Mass of empty Can (MC)	gram	19.66	6.176	6.33	6.499	5.534	
Mass of Can + Wet Soil (McWs)	gram	34.36	20.76	21.62	12.25	11.25	
Mass of Can + Dry Soil (McDs)	gram	28.61	14.72	15.16	10.62	9.638	
Mass of Dry soil (MDs)	gram	8.951	8.547	8.83	4.121	4.104	
Mass of Water (Mw)	gram	5.75	6.04	6.46	1.63	1.61	
Water Content (w)	%	64.23	70.63	73.16	39.55	39.28	
Liquid Limit (LL)	%	**69.4**					
Plastic Limit (PL)	%	**39.4**					
PLastic Index (PI)	%	**30.0**					



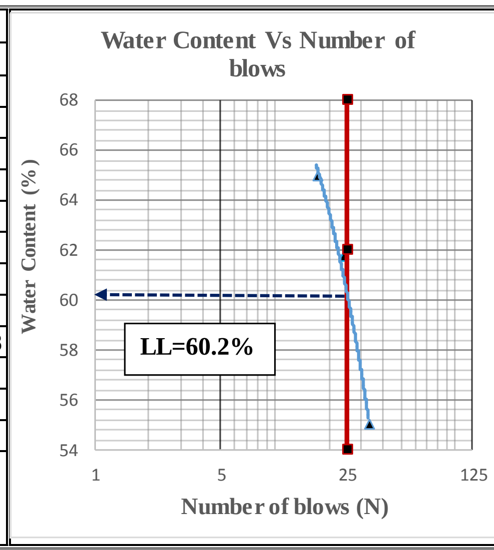
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Town Municipality Office		Test Pit		5 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	27	19		
Can Code		G	G53	NB	3A	G3T2
Mass of empty Can (MC)	gram	17.81	17.39	17.39	17.4	17.53
Mass of Can + Wet Soil (McWs)	gram	33.31	31.91	32.06	24.47	24.285
Mass of Can + Dry Soil (McDs)	gram	27.57	26.09	25.59	22.49	22.4
Mass of Dry soil (MDs)	gram	9.76	8.7	8.196	5.09	4.87
Mass of Water (Mw)	gram	5.74	5.82	6.47	1.98	1.89
Water Content (w)	%	58.81	66.90	78.99	38.90	38.71
Liquid Limit (LL)	%	**69.6**				
Plastic Limit (PL)	%	**38.8**				
PLastic Index (PI)	%	**30.8**				



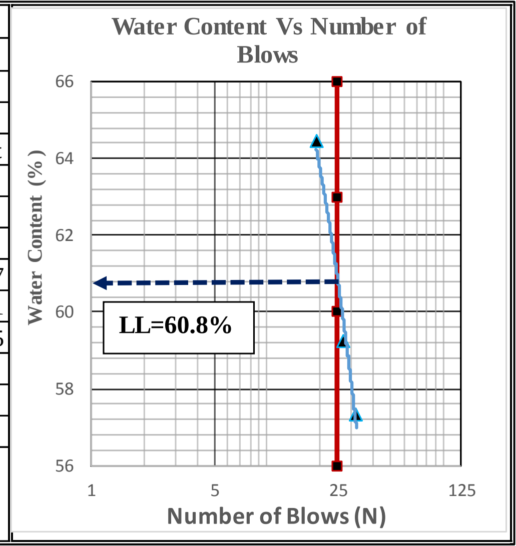
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Town Municipality Office		Test Pit		5 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	31	22	15		
Can Code		G3T2	P5	T2C1	50	G
Mass of empty Can (MC)	gram	18.35	19.74	18.61	17.73	17.638
Mass of Can + Wet Soil (McWs)	gram	35.53	36.35	35.21	25.65	25.72
Mass of Can + Dry Soil (McDs)	gram	28.97	29.52	28.2	23.5	23.526
Mass of Dry soil (MDs)	gram	10.62	9.78	9.587	5.768	5.888
Mass of Water (Mw)	gram	6.56	6.83	7.01	2.15	2.19
Water Content (w)	%	61.77	69.84	73.12	37.27	37.26
Liquid Limit (LL)	%	**66.6**				
Plastic Limit (PL)	%	**37.3**				
PLastic Index (PI)	%	**29.3**				



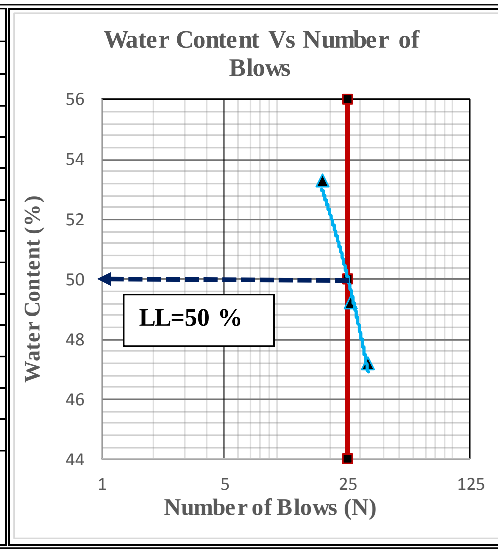
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Town Municipality Office		Test Pit		5 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	33	24	17		
Can Code		A2	30	C2	G2	20
Mass of empty Can (MC)	gram	8.36	8.15	6.403	17.68	17.53
Mass of Can + Wet Soil (McWs)	gram	22.71	21.77	21.71	24.39	24.45
Mass of Can + Dry Soil (McDs)	gram	17.62	16.57	15.69	22.75	22.738
Mass of Dry soil (MDs)	gram	9.26	8.42	9.282	5.071	5.208
Mass of Water (Mw)	gram	5.09	5.20	6.03	1.639	1.71
Water Content (w)	%	54.97	61.76	64.95	32.32	32.87
Liquid Limit (LL)	%	**60.2**				
Plastic Limit (PL)	%	**32.6**				
PLastic Index (PI)	%	**27.6**				



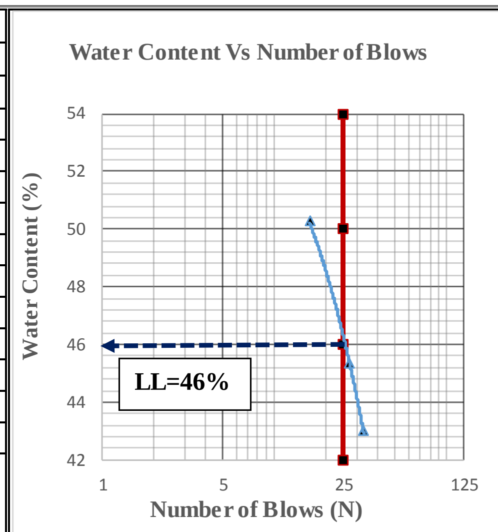
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka High School			Test Pit	6 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	27	19		
Can Code		P2	A3	G3T3	B3	T1C1
Mass of empty Can (MC)	gram	16.59	15.99	17.01	17.3	17.617
Mass of Can + Wet Soil (McWs)	gram	31.03	30.23	31.91	24.25	24.341
Mass of Can + Dry Soil (McDs)	gram	25.77	24.93	26.07	22.51	22.655
Mass of Dry soil (MDs)	gram	9.179	8.94	9.06	5.21	5.038
Mass of Water (Mw)	gram	5.26	5.30	5.84	1.741	1.69
Water Content (w)	%	57.33	59.26	64.46	33.42	33.47
Liquid Limit (LL)	%	**60.8**				
Plastic Limit (PL)	%	**33.4**				
PLastic Index (PI)	%	**27.4**				



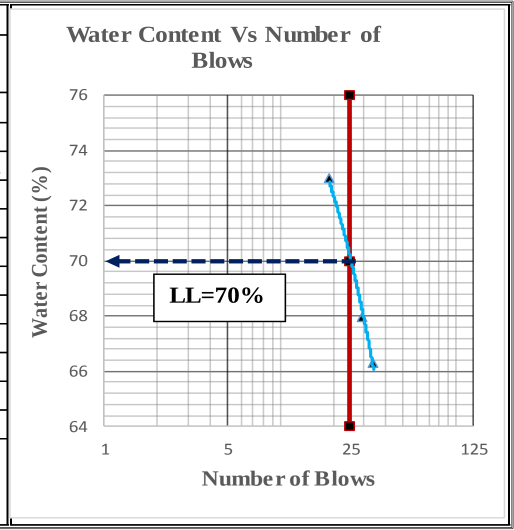
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka High School			Test Pit	6 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	33	26	18		
Can Code		P2	A3	B3	P1	4
Mass of empty Can (MC)	gram	16.26	13.44	15.54	16.5	17.16
Mass of Can + Wet Soil (McWs)	gram	30.73	29.75	31.85	24.03	23.64
Mass of Can + Dry Soil (McDs)	gram	26.09	24.37	26.18	22.32	22.17
Mass of Dry soil (MDs)	gram	9.83	10.93	10.64	5.82	5.01
Mass of Water (Mw)	gram	4.64	5.38	5.67	1.71	1.47
Water Content (w)	%	47.20	49.22	53.29	29.38	29.34
Liquid Limit (LL)	%	**50.0**				
Plastic Limit (PL)	%	**29.4**				
PLastic Index (PI)	%	**20.6**				



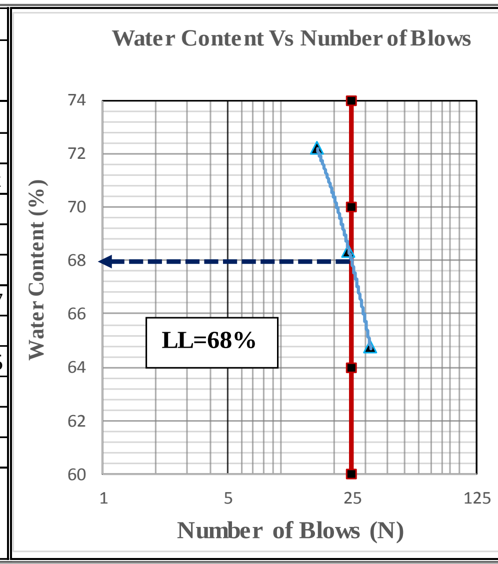
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka High School			Test Pit	6 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	33	27	16		
Can Code		37	12	58	49	29
Mass of empty Can (MC)	gram	6.078	6.458	5.717	5.432	6.145
Mass of Can + Wet Soil (McWs)	gram	22.31	22.38	21.41	11.55	13.21
Mass of Can + Dry Soil (McDs)	gram	17.43	17.41	16.16	10.21	11.65
Mass of Dry soil (MDs)	gram	11.35	10.95	10.44	4.778	5.505
Mass of Water (Mw)	gram	4.88	4.97	5.25	1.34	1.56
Water Content (w)	%	43.01	45.33	50.27	28.05	28.34
Liquid Limit (LL)	%	**46.0**				
Plastic Limit (PL)	%	**28.2**				
PLastic Index (PI)	%	**17.8**				



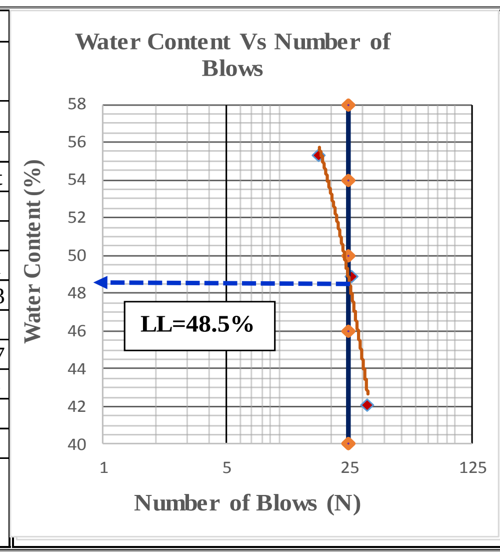
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	New Generation KG School			Test Pit		7 @ 1m
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	29	19		
Can Code		31	C4	27	3	C12
Mass of empty Can (MC)	gram	8.149	17.59	5.75	16.39	16.22
Mass of Can + Wet Soil (McWs)	gram	22.89	32.27	23.43	22.88	23.2
Mass of Can + Dry Soil (McDs)	gram	17.01	26.33	15.97	20.96	21.13
Mass of Dry soil (MDs)	gram	8.861	8.74	10.22	4.57	4.91
Mass of Water (Mw)	gram	5.88	5.94	7.46	1.92	2.07
Water Content (w)	%	66.30	67.96	72.99	42.01	42.16
Liquid Limit (LL)	%	**70.0**				
Plastic Limit (PL)	%	**42.1**				
PLastic Index (PI)	%	**27.9**				



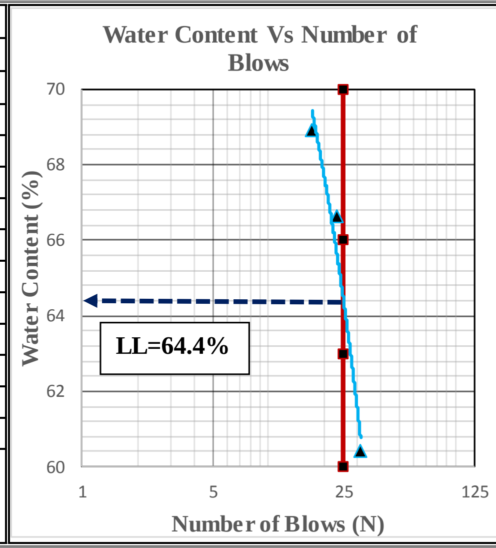
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	New Generation KG School			Test Pit		7 @ 2m
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	24	16		
Can Code		2	MK	3	6	G7
Mass of empty Can (MC)	gram	17.44	14.56	18.12	17.15	17.497
Mass of Can + Wet Soil (McWs)	gram	31.25	29.26	32.68	23.14	23.24
Mass of Can + Dry Soil (McDs)	gram	25.82	23.29	26.57	21.51	21.685
Mass of Dry soil (MDs)	gram	8.384	8.73	8.452	4.359	4.188
Mass of Water (Mw)	gram	5.43	5.97	6.11	1.632	1.56
Water Content (w)	%	64.75	68.38	72.24	37.44	37.13
Liquid Limit (LL)	%	**68.0**				
Plastic Limit (PL)	%	**37.3**				
PLastic Index (PI)	%	**30.7**				



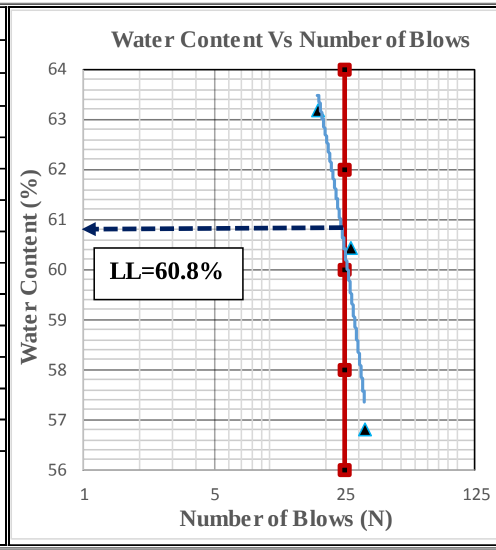
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	New Generation KG School			Test Pit		7 @ 3m
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	26	17		
Can Code		B1	G7	3	G3T3	HC11
Mass of empty Can (MC)	gram	18.13	17.89	16.92	17.76	17.883
Mass of Can + Wet Soil (McWs)	gram	33.56	33.85	31.66	25.32	24.35
Mass of Can + Dry Soil (McDs)	gram	28.99	28.61	26.41	23.64	22.897
Mass of Dry soil (MDs)	gram	10.86	10.72	9.487	5.877	5.014
Mass of Water (Mw)	gram	4.57	5.24	5.25	1.68	1.45
Water Content (w)	%	42.09	48.88	55.34	28.59	28.98
Liquid Limit (LL)	%	**48.5**				
Plastic Limit (PL)	%	**28.8**				
PLastic Index (PI)	%	**19.7**				



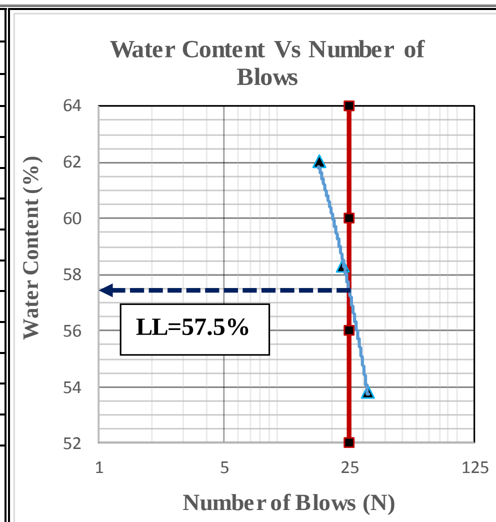
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Hospital		Test Pit		8 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	31	23	17		
Can Code		C2	A2	3	60	38
Mass of empty Can (MC)	gram	6.46	6.082	13.02	6.355	6.165
Mass of Can + Wet Soil (McWs)	gram	18.25	19.44	27.21	15.23	14.61
Mass of Can + Dry Soil (McDs)	gram	13.81	14.1	21.42	12.96	12.43
Mass of Dry soil (MDs)	gram	7.35	8.017	8.4	6.605	6.265
Mass of Water (Mw)	gram	4.44	5.34	5.79	2.27	2.18
Water Content (w)	%	60.41	66.62	68.93	34.37	34.80
Liquid Limit (LL)	%	**64.4**				
Plastic Limit (PL)	%	**34.6**				
PLastic Index (PI)	%	**29.8**				



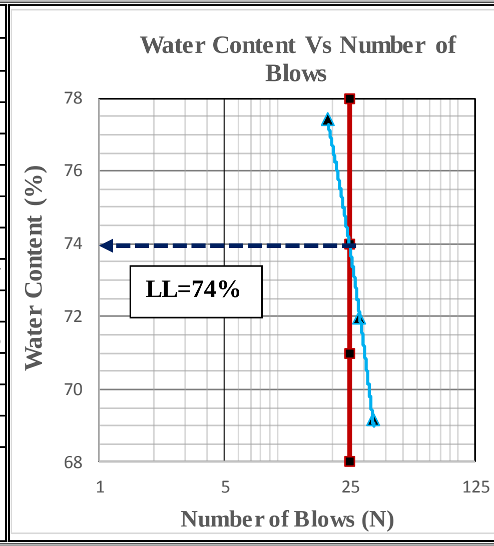
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Hospital		Test Pit		8 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	27	18		
Can Code		R1	A20	13	56	60
Mass of empty Can (MC)	gram	6.92	19.84	6.291	6.279	6.459
Mass of Can + Wet Soil (McWs)	gram	17.99	30.54	19.05	12.72	12.82
Mass of Can + Dry Soil (McDs)	gram	13.98	26.51	14.11	11.14	11.27
Mass of Dry soil (MDs)	gram	7.06	6.67	7.819	4.861	4.811
Mass of Water (Mw)	gram	4.01	4.03	4.94	1.58	1.55
Water Content (w)	%	56.80	60.42	63.18	32.50	32.22
Liquid Limit (LL)	%	**60.8**				
Plastic Limit (PL)	%	**32.4**				
PLastic Index (PI)	%	**28.4**				



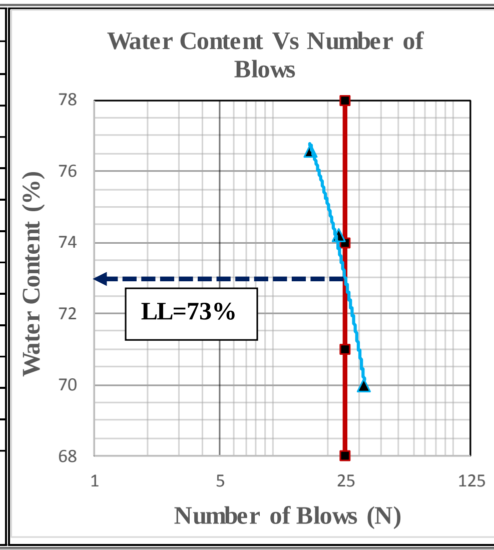
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Hospital		Test Pit		8 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	23	17		
Can Code		A20	38	56	13	49
Mass of empty Can (MC)	gram	19.66	6.176	6.13	6.479	5.514
Mass of Can + Wet Soil (McWs)	gram	34.66	20.51	20.66	11.51	10.27
Mass of Can + Dry Soil (McDs)	gram	29.41	15.23	15.1	10.31	9.137
Mass of Dry soil (MDs)	gram	9.75	9.054	8.966	3.826	3.623
Mass of Water (Mw)	gram	5.25	5.28	5.56	1.205	1.13
Water Content (w)	%	53.85	58.32	62.06	31.50	31.27
Liquid Limit (LL)	%	**57.5**				
Plastic Limit (PL)	%	**31.4**				
PLastic Index (PI)	%	**26.1**				



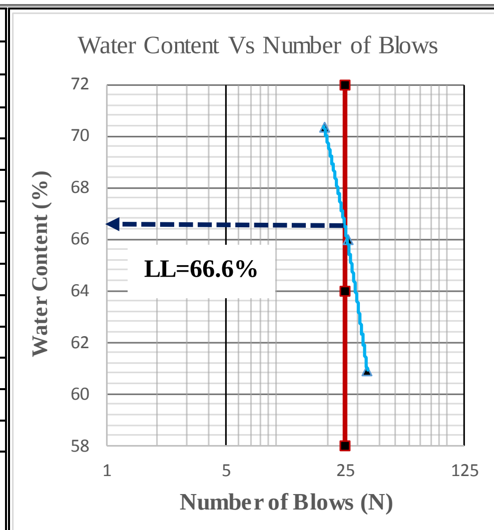
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Preparatory School			Test Pit	9 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	28	19		
Can Code		P2	A3	G3T3	B3	T1C1
Mass of empty Can (MC)	gram	17.14	16.69	17.1	17.3	17.517
Mass of Can + Wet Soil (McWs)	gram	30.76	30.38	32.35	24.72	24.84
Mass of Can + Dry Soil (McDs)	gram	25.19	24.65	25.7	22.51	22.655
Mass of Dry soil (MDs)	gram	8.05	7.963	8.595	5.21	5.138
Mass of Water (Mw)	gram	5.57	5.73	6.65	2.21	2.19
Water Content (w)	%	69.19	71.96	77.41	42.42	42.53
Liquid Limit (LL)	%	**74.0**				
Plastic Limit (PL)	%	**42.5**				
PLastic Index (PI)	%	**31.5**				



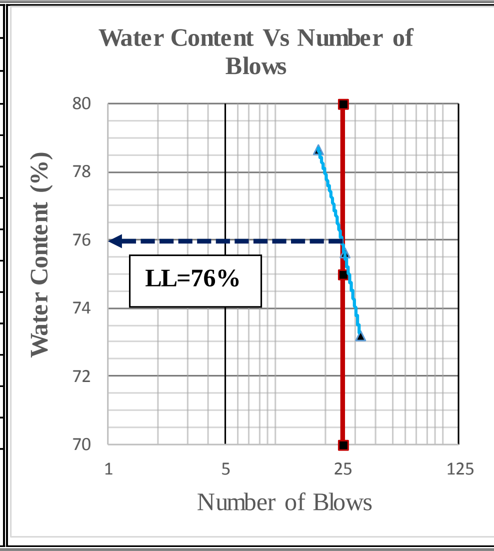
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Preparatory School			Test Pit	9 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	23	16		
Can Code		P2	A3	B3	P1	4
Mass of empty Can (MC)	gram	18.23	15.88	18.3	17.8	17.54
Mass of Can + Wet Soil (McWs)	gram	31.13	28.65	30.94	24.29	24.26
Mass of Can + Dry Soil (McDs)	gram	25.82	23.21	25.46	22.38	22.29
Mass of Dry soil (MDs)	gram	7.587	7.331	7.158	4.58	4.75
Mass of Water (Mw)	gram	5.31	5.44	5.48	1.91	1.97
Water Content (w)	%	69.99	74.19	76.59	41.70	41.47
Liquid Limit (LL)	%	**73.0**				
Plastic Limit (PL)	%	**41.6**				
PLastic Index (PI)	%	**31.4**				



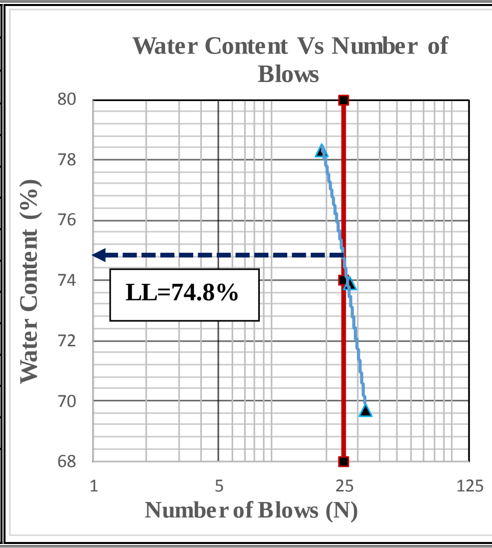
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Seka Preparatory School			Test Pit	9 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	34	26	19		
Can Code		37	12	58	49	29
Mass of empty Can (MC)	gram	7.978	9.758	6.317	5.612	6.102
Mass of Can + Wet Soil (McWs)	gram	21.18	22.95	20.35	11.05	12.66
Mass of Can + Dry Soil (McDs)	gram	16.18	17.71	14.56	9.632	10.94
Mass of Dry soil (MDs)	gram	8.205	7.947	8.239	4.02	4.838
Mass of Water (Mw)	gram	5.00	5.25	5.79	1.418	1.72
Water Content (w)	%	60.90	66.00	70.32	35.27	35.55
Liquid Limit (LL)	%	**66.6**				
Plastic Limit (PL)	%	**35.4**				
PLastic Index (PI)	%	**31.2**				



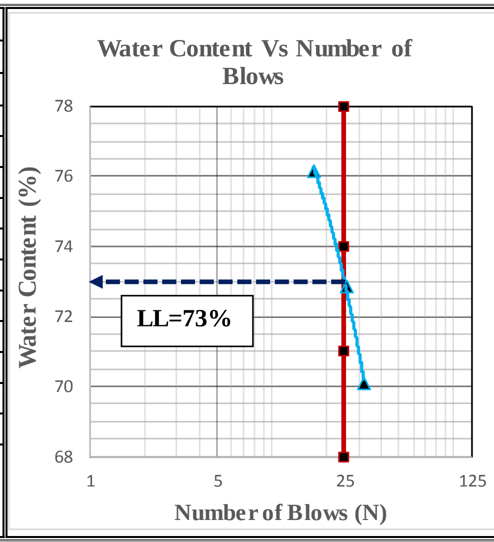
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Lideta Orthodox Church			Test Pit	10 @ 1m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	26	18		
Can Code		31	C4	27	3	C12
Mass of empty Can (MC)	gram	8.239	17.87	7.75	16.59	16.32
Mass of Can + Wet Soil (McWs)	gram	22.58	32.73	24.17	22.76	23.16
Mass of Can + Dry Soil (McDs)	gram	16.52	26.33	16.94	20.99	21.19
Mass of Dry soil (MDs)	gram	8.279	8.46	9.19	4.395	4.87
Mass of Water (Mw)	gram	6.06	6.40	7.23	1.775	1.97
Water Content (w)	%	73.22	75.65	78.67	40.39	40.45
Liquid Limit (LL)	%	**76.0**				
Plastic Limit (PL)	%	**40.4**				
PLastic Index (PI)	%	**35.6**				



Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Lideta Orthodox Church			Test Pit	10 @ 2m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	33	27	19		
Can Code		2	MK	3	6	G7
Mass of empty Can (MC)	gram	17.97	15.53	18.72	17.15	17.287
Mass of Can + Wet Soil (McWs)	gram	31.36	28.68	32.01	23.42	23.73
Mass of Can + Dry Soil (McDs)	gram	25.86	23.09	26.17	21.59	21.85
Mass of Dry soil (MDs)	gram	7.89	7.564	7.454	4.441	4.563
Mass of Water (Mw)	gram	5.50	5.59	5.84	1.83	1.88
Water Content (w)	%	69.71	73.90	78.29	41.21	41.20
Liquid Limit (LL)	%	**74.8**				
Plastic Limit (PL)	%	**41.2**				
PLastic Index (PI)	%	**33.6**				



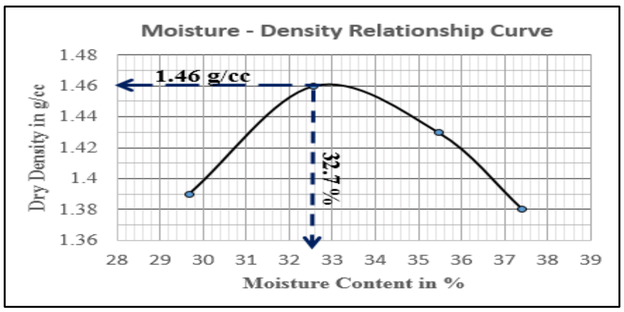
Test	ATTERBERG LIMITS TEST (ASTM D 4318-98)					
Site	Lideta Orthodox Church			Test Pit	10 @ 3m	
Determination of Liquid Limit, Plastic Limit and Plastic Index						
	Units					
Test		**Liquid Limit**			**Plastic Limit**	
Trial number		1	2	3	1	2
Number of Blows	N	32	26	17		
Can Code		B1	G7	3	G3T3	HC11
Mass of empty Can (MC)	gram	19.03	18.59	16.78	17.56	17.583
Mass of Can + Wet Soil (McWs)	gram	35.44	34.84	32.65	26.14	25.12
Mass of Can + Dry Soil (McDs)	gram	28.68	27.99	25.79	23.64	22.897
Mass of Dry soil (MDs)	gram	9.648	9.401	9.007	6.077	5.314
Mass of Water (Mw)	gram	6.76	6.85	6.86	2.5	2.22
Water Content (w)	%	70.08	72.86	76.16	41.14	41.83
Liquid Limit (LL)	%	**73.0**				
Plastic Limit (PL)	%	**41.5**				
PLastic Index (PI)	%	**31.5**				



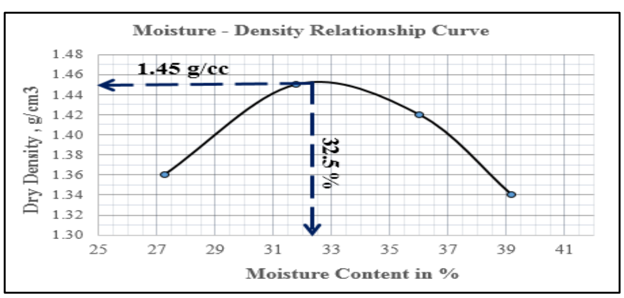
Appendix M

Modified Compaction Laboratory Analysis and Test result of all Samples

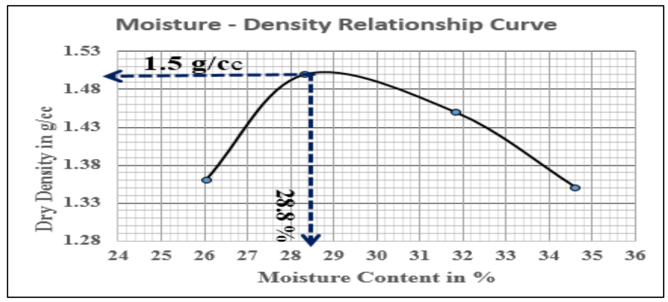
Site	Agricultural Office						Test Pit	1 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10240.1		10514.7		10510.2		10433.5	
Weight of Mold	gram	6399.2		6399.2		6399.2		6399.2	
Weight of Wet soil	gram	3840.9		4115.5		4111		4034.3	
Volume of Mold	cc	2124		2124		2124		2124	
Wet Density	g/cc.	1.81		1.94		1.94		1.90	
Moisture Content Determination									
Container Code		G7	II	DH	D	B1	P2	B3	HC51
Weight of cont. + wet soil	gram	75.5	87.1	114.2	155.8	83.42	88.25	82.38	81.5
Weight of cont. + dry soil	gram	62.2	71.2	90.2	124.9	66.26	69.83	64.66	64.2
Weight of water	gram	13.2	15.9	24	30.86	17.16	18.42	17.72	17.4
Weight of container	gram	17.4	18	17	29.59	18.24	17.49	17.4	17.7
Weight of Dry soil	gram	44.8	53.2	73.2	95.33	48.02	52.34	47.26	46.5
Dry Density and Moisture Content Determination									
Moisture content	%	29.50	29.83	32.77	32.37	35.74	35.19	37.49	37.35
Avarege Moisture content	%	29.67		32.57		35.46		37.42	
Dry Density	gr/cc.	1.39		1.46		1.43		1.38	
Maximum Dry Density	gr/cc.	**1.46**							
Optimum Moisture Content	%	**32.7**							



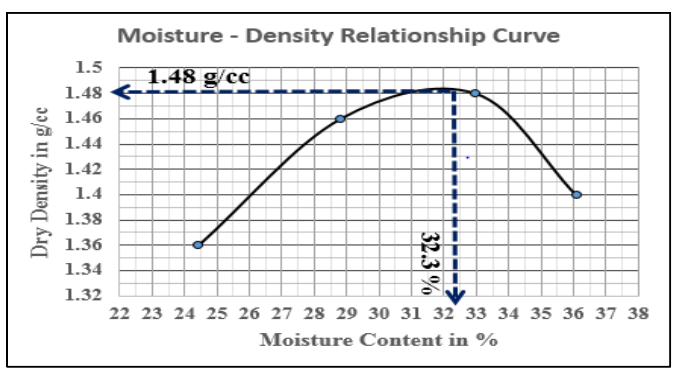
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Agricultural Office						Test Pit	1 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10180.8		10502.7		10487.3		10369.2	
Weight of Mold	gram	6508.9		6508.9		6508.9		6508.9	
Weight of Wet soil	gram	3671.9		4103.5		4088.1		3970	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.73		1.93		1.92		1.87	
Moisture Content Determination									
Container Code		P3	G	65	G19	C	UC	O3-2	P-3
Weight of cont. + wet soil	gram	121	116	192	200.1	112.21	92.36	165.4	142
Weight of cont. + dry soil	gram	100	99.2	154	159	91.16	72.37	130.4	109
Weight of water	gram	20.5	16.7	38.00	41.14	21.05	19.99	34.94	32.7
Weight of container	gram	25.2	37.9	37.5	34.24	32.86	16.72	41.25	26
Weight of Dry soil	gram	75.2	61.3	117	124.7	58.3	55.65	89.17	83.4
Dry Density and Moisture Content Determination									
Moisture content	%	27.24	27.25	32.58	32.99	36.11	35.92	39.18	39.20
Avarege Moisture content	%	27.25		32.78		36.01		39.19	
Dry Density	gr/cc	1.36		1.45		1.42		1.34	
Maximum Dry Density	gr/cc	**1.45**							
Optimum Moisture Content	%	**32.5**							



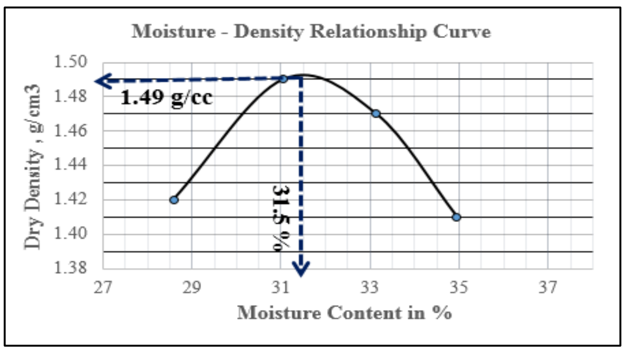
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Agricultural Office						Test Pit	1 @ 3m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10050.6		10500.6		10460.4		10268.8	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3651.4		4101.4		4061.2		3869.6	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.72		1.93		1.91		1.82	
Moisture Content Determination									
Container Code		W11	G3T3	O2-2	J41	P3	T1	P15	O2-1
Weight of cont. + wet soil	gram	141	146	110	118	120.7	137	125.5	156
Weight of cont. + dry soil	gram	120	123	92.3	99.19	100.2	113	99.69	123
Weight of water	gram	20.7	22.2	18.2	18.82	20.42	24.1	25.81	32.6
Weight of container	gram	40.8	37.9	28.3	32.71	35.97	37.7	25.41	28.7
Weight of Dry soil	gram	79.4	85.4	64	66.48	64.26	75.5	74.28	94.5
Dry Density and Moisture Content Determination									
Moisture content	%	26.10	26.00	28.36	28.31	31.78	31.89	34.75	34.49
Avarege Moisture content	%	26.05		28.33		31.83		34.62	
Dry Density	gr/cc	1.36		1.50		1.45		1.35	
Maximum Dry Density	gr/cc	**1.50**							
Optimum Moisture Content	%	**28.80**							



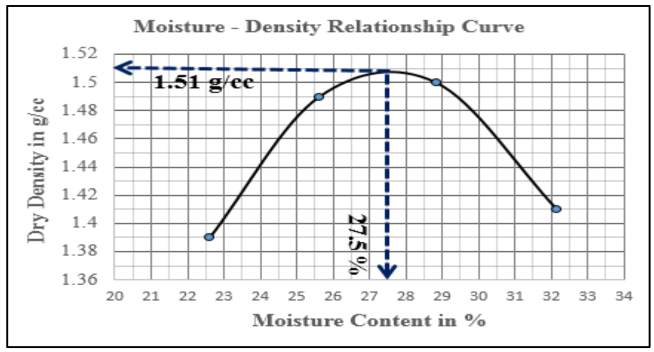
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Bus Station						Test Pit	2 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10005.4		10405.7		10583.6		10446.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3606.2		4006.5		4184.4		4047.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.70		1.89		1.97		1.91	
Moisture Content Determination									
Container Code		G19	J41	A-13	T2	P66	G	2	P15
Weight of cont. + wet soil	gram	90.4	139	203	218.9	197	175	181.4	242
Weight of cont. + dry soil	gram	76.1	118	165	178.6	157.4	139	142.6	187
Weight of water	gram	14.3	20.8	37.2	40.32	39.55	35.3	38.86	55.4
Weight of container	gram	17.8	32.7	36.6	38.44	37.45	32.4	34.64	33.6
Weight of Dry soil	gram	58.3	85.3	129	140.2	120	107	107.9	153
Dry Density and Moisture Content Determination									
Moisture content	%	24.50	24.33	28.86	28.77	32.97	32.99	36.01	36.15
Avarege Moisture content	%	24.42		28.81		32.98		36.08	
Dry Density	gr/cc	1.36		1.46		1.48		1.40	
Maximum Dry Density	gr/cc	**1.48**							
Optimum Moisture Content	%	**32.3**							



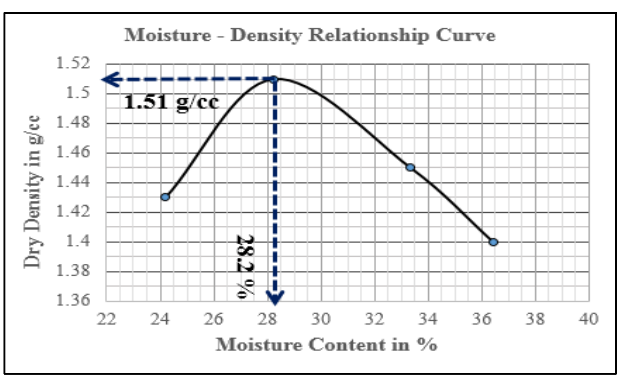
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Seka Town Bus Station						Test Pit		2 @ 2m
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10374.1		10558.8		10551.5		10440.3	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3865.2		4159.6		4152.3		4041.1	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.82		1.96		1.95		1.90	
Moisture Content Determination									
Container Code		P15	O2-2	14	UC	HC11	C	G19	65
Weight of cont. + wet soil	gram	137	130	153	122.8	128.32	200	162.7	249
Weight of cont. + dry soil	gram	112	107	121	97.69	100.9	159	129.4	195
Weight of water	gram	24.7	22.4	32.2	25.12	27.42	41.9	33.25	54.9
Weight of container	gram	25.4	28.7	17.5	16.73	17.67	32.9	34.25	37.5
Weight of Dry soil	gram	86.7	78.3	104	80.96	83.23	126	95.17	157
Dry Density and Moisture Content Determination									
Moisture content	%	28.50	28.65	31.07	31.03	32.94	33.31	34.94	34.95
Avarege Moisture content	%	28.58		31.05		33.13		34.95	
Dry Density	gr/cc	1.42		1.49		1.47		1.41	
Maximum Dry Density	gr/cc	1.49							
Optimum Moisture Content	%	31.5							



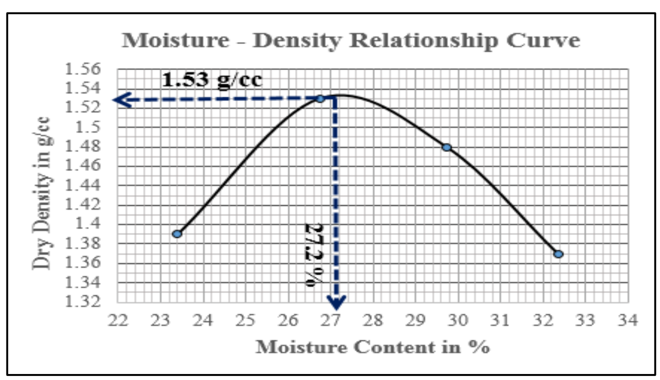
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Police Office						Test Pit		3 @ 1m
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10031.5		10385.7		10515.6		10370.3	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3632.3		3986.5		4116.4		3971.1	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.71		1.88		1.94		1.87	
Moisture Content Determination									
Container Code		10G	47	G19	W11	C13T2	T2	B1	O4-3
Weight of cont. + wet soil	gram	99	88.8	130	141.7	135.71	101.7	97.01	99.4
Weight of cont. + dry soil	gram	84	75.6	111	121	113.2	82.84	77.85	79.6
Weight of water	gram	15	13.2	19.4	20.73	22.52	18.83	19.16	19.9
Weight of container	gram	17.7	17.1	34.3	40.8	34.95	17.58	18.23	17.7
Weight of Dry soil	gram	66.3	58.5	76.5	80.21	78.24	65.26	59.62	61.9
Dry Density and Moisture Content Determination									
Moisture content	%	22.62	22.58	25.40	25.84	28.78	28.85	32.14	32.16
Avarege Moisture content	%	22.60		25.62		28.82		32.15	
Dry Density	gr/cc	1.39		1.49		1.50		1.41	
Maximum Dry Density	gr/cc	**1.51**							
Optimum Moisture Content	%	**27.5**							



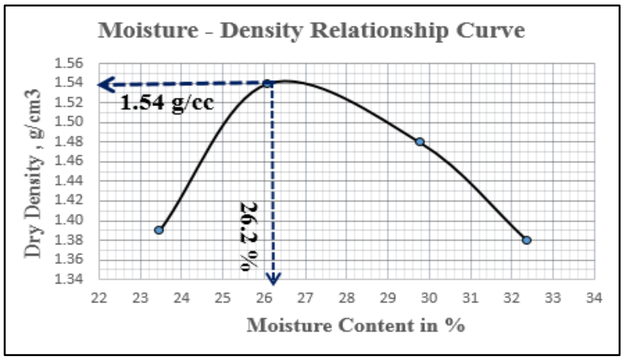
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Town Bus Station						Test Pit		2 @ 3m
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10180.3		10516.8		10504.7		10460.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3781.1		4117.6		4105.5		4061.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.78		1.94		1.93		1.91	
Moisture Content Determination									
Container Code		P15	P66	ZE	2	A-1C	G	T2	F
Weight of cont. + wet soil	gram	161	208	115	145.1	237.1	193	133.5	142
Weight of cont. + dry soil	gram	136	175	96.7	120.9	190.5	153	108	114
Weight of water	gram	24.9	33.2	18	24.26	46.56	40.6	25.51	28.1
Weight of container	gram	33.6	37.5	33.1	34.64	49.75	32.2	38.44	36.4
Weight of Dry soil	gram	103	137	63.6	86.22	140.8	121	69.58	77.8
Dry Density and Moisture Content Determination									
Moisture content	%	24.21	24.19	28.28	28.14	33.08	33.59	36.66	36.16
Avarege Moisture content	%	24.20		28.21		33.34		36.41	
Dry Density	gr/cc	1.43		1.51		1.45		1.40	
Maximum Dry Density	gr/cc	**1.51**							
Optimum Moisture Content	%	**28.2**							



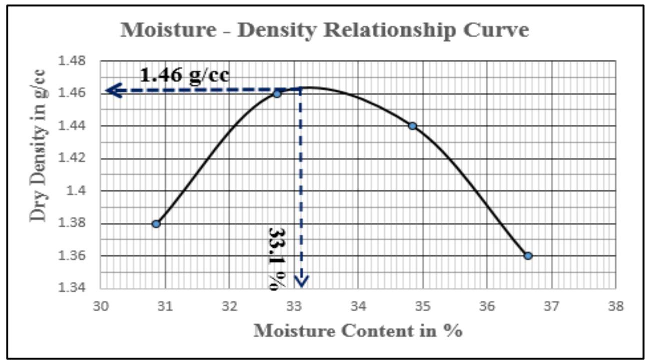
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Police Office						Test Pit		3 @ 2m
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10055.4		10525.2		10475.8		10262.1	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3656.2		4126		4076.6		3862.9	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.72		1.94		1.92		1.82	
Moisture Content Determination									
Container Code		A-13	O3-1	M	P65	ZE	CS3	P66	P6
Weight of cont. + wet soil	gram	110	107	114	122.6	136.42	153	121.3	150
Weight of cont. + dry soil	gram	96.1	94	98.2	104.6	112.6	126	100.7	123
Weight of water	gram	14	13.4	15.5	17.93	23.8	27.4	20.52	27.4
Weight of container	gram	36.6	36.7	40.2	37.8	33.08	32.9	37.45	37.7
Weight of Dry soil	gram	59.6	57.3	58	66.84	79.54	92.7	63.29	84.8
Dry Density and Moisture Content Determination									
Moisture content	%	23.46	23.35	26.66	26.83	29.92	29.53	32.42	32.27
Avarege Moisture content	%	23.40		26.74		29.73		32.35	
Dry Density	gr/cc	1.39		1.53		1.48		1.37	
Maximum Dry Density	gr/cc	1.53							
Optimum Moisture Content	%	27.2							



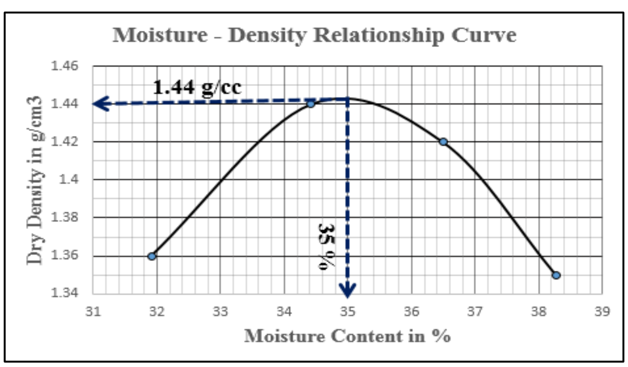
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Police Office					Test Pit		3 @ 3m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10152.1		10525.3		10480.3		10288.2	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3643.2		4126.1		4081.1		3889	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.72		1.94		1.92		1.83	
Moisture Content Determination									
Container Code		O3-5	A	O3-3	O5-1	O6-2	NB	29	O2-3
Weight of cont. + wet soil	gram	132	166	81.1	86.12	118.56	110	78.48	102
Weight of cont. + dry soil	gram	111	142	68	71.89	95.2	89.1	63.65	81.4
Weight of water	gram	22	24.1	13.1	14.23	23.36	21.2	14.83	20.8
Weight of container	gram	17.6	37.7	17.5	17.48	17.15	17.6	17.55	17.7
Weight of Dry soil	gram	92.9	104	50.5	54.41	78.05	71.5	46.1	63.7
Dry Density and Moisture Content Determination									
Moisture content	%	23.67	23.23	25.99	26.15	29.93	29.61	32.17	32.57
Avarege Moisture content	%	23.45		26.07		29.77		32.37	
Dry Density	gr/cc	1.39		1.54		1.48		1.38	
Maximum Dry Density	gr/cc	**1.54**							
Optimum Moisture Content	%	**26.2**							



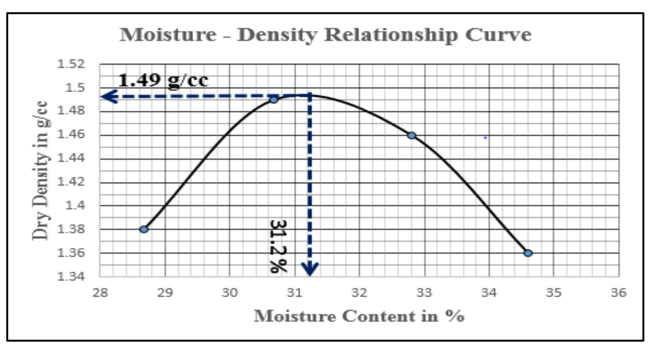
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Administration Office					Test Pit		4 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10247.8		10528.7		10520.5		10362.9	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3848.6		4129.5		4121.3		3963.7	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.81		1.94		1.94		1.87	
Moisture Content Determination									
Container Code		14	P15	O2-2	HC11	C3	T2	P2	SG=3
Weight of cont. + wet soil	gram	90.1	109	112	101.6	121.5	92.65	88.64	136
Weight of cont. + dry soil	gram	73	89.3	91.5	80.79	96.99	73.25	69.6	106
Weight of water	gram	17.2	19.7	20.4	20.78	24.46	19.4	19.04	29.7
Weight of container	gram	17.5	25.4	28.7	17.67	26.75	17.58	17.66	25.4
Weight of Dry soil	gram	55.5	63.9	62.7	63.12	70.24	55.67	51.94	81
Dry Density and Moisture Content Determination									
Moisture content	%	30.90	30.82	32.54	32.92	34.82	34.85	36.66	36.61
Avarege Moisture content	%	30.86		32.73		34.84		36.63	
Dry Density	gr/cc	1.38		1.46		1.44		1.37	
Maximum Dry Density	gr/cc	**1.46**							
Optimum Moisture Content	%	**33.1**							



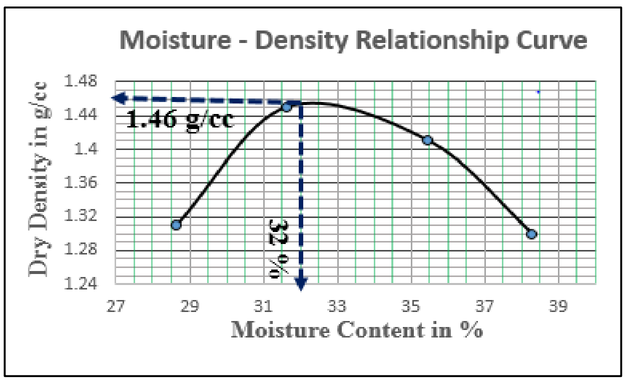
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Administration Office					Test Pit		4 @ 1 m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10222.6		10524.3		10520.2		10365.6	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3823.4		4125.1		4121		3966.4	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.80		1.94		1.94		1.87	
Moisture Content Determination									
Container Code		B1	T2	O2-3	GS3	1A	D	A-1C	9
Weight of cont. + wet soil	gram	72.9	135	116	128.8	112.6	148.4	175.6	169
Weight of cont. + dry soil	gram	59.7	106	90.6	100.3	87.26	116.59	140.9	131
Weight of water	gram	13.2	28.4	25.2	28.46	25.34	31.81	34.72	38.1
Weight of container	gram	18.2	17.6	17.7	17.5	17.73	29.58	49.68	32.4
Weight of Dry soil	gram	41.5	88.8	73	82.8	69.53	87.01	91.24	98.9
Dry Density and Moisture Content Determination									
Moisture content	%	31.79	32.03	34.47	34.37	36.44	36.56	38.05	38.49
Avarege Moisture content	%	31.91		34.42		36.50		38.27	
Dry Density	gr/cc	1.36		1.44		1.42		1.35	
Maximum Dry Density	gr/cc	1.44							
Optimum Moisture Content	%	35							



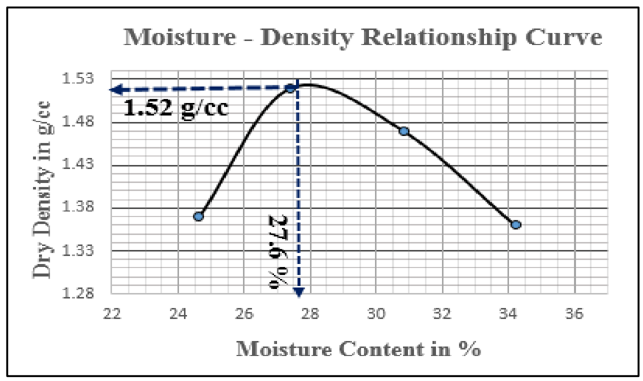
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Administration Office					Test Pit		4 @ 3m	
Wet Density Determination									
) COMPACTION TEST (AAS	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10182.6		10539.7		10515.6		10358.7	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3783.4		4140.5		4116.4		3959.5	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.78		1.95		1.94		1.86	
Moisture Content Determination									
Container Code		HC11	G19	5	RG	O6-3	O5-2	O6-12	O6-11
Weight of cont. + wet soil	gram	115	232	155	206	86.15	94.35	90.21	106
Weight of cont. + dry soil	gram	92.8	189	124	163.8	69.29	75.27	70.81	82.6
Weight of water	gram	21.8	42.9	30.5	42.16	16.86	19.08	19.40	23.9
Weight of container	gram	17.7	37.9	26	25.2	17.17	17.91	17.38	17.9
Weight of Dry soil	gram	75.1	151	98.4	138.6	52.12	57.36	53.43	64.7
Dry Density and Moisture Content Determination									
Moisture content	%	28.98	28.36	30.94	30.42	32.35	33.26	36.31	36.91
Avarege Moisture content	%	28.67		30.68		32.81		36.61	
Dry Density	gr/cc	1.38		1.49		1.46		1.36	
Maximum Dry Density	gr/cc	1.49							
Optimum Moisture Content	%	31.2							



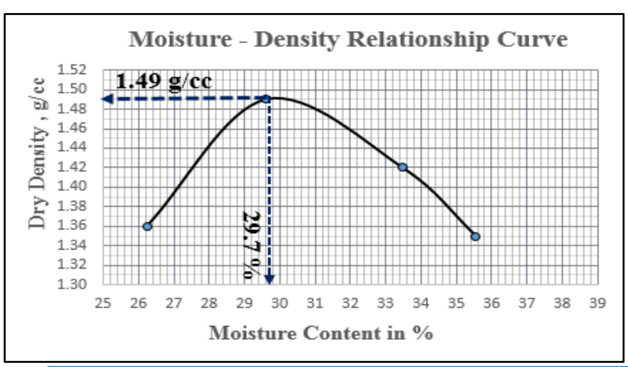
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Town Municipality Office					Test Pit		5 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	9992.1		10466.7		10455.2		10231.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3592.9		4067.5		4056		3832.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.69		1.92		1.91		1.80	
Moisture Content Determination									
Container Code		G7	II	DH	D	B1	P2	B3	HC51
Weight of cont. + wet soil	gram	73.8	85.21	112	154	82.02	87.25	81.7	81.16
Weight of cont. + dry soil	gram	61.2	70.24	89.2	124	65.47	68.83	64	63.52
Weight of water	gram	12.6	14.97	22.7	30.1	16.55	18.42	17.7	17.64
Weight of container	gram	17.4	18.01	17	29.6	18.24	17.49	17.4	17.68
Weight of Dry soil	gram	43.8	52.23	72.2	94.3	47.23	51.34	46.6	45.84
Dry Density and Moisture Content Determination									
Moisture content	%	28.63	28.66	31.42	31.86	35.04	35.88	38.09	38.48
Avarege Moisture content	%	28.64		31.64		35.46		38.28	
Dry Density	gr/cc	1.31		1.45		1.41		1.30	
Maximum Dry Density	gr/cc	**1.45**							
Optimum Moisture Content	%	**32**							



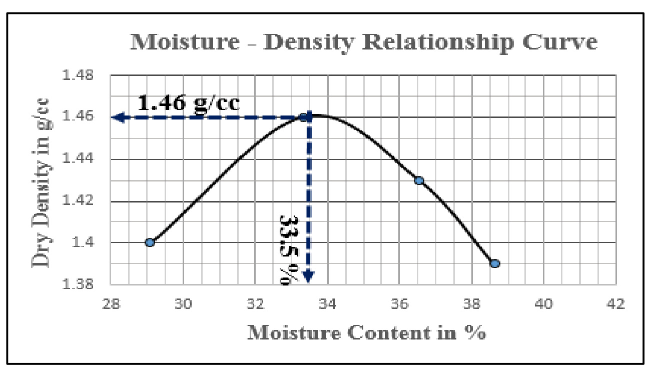
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Town Municipality Office					Test Pit		5 @ 3m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10038.6		10518.6		10495.4		10288.8	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3639.4		4119.4		4096.2		3889.6	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.71		1.94		1.93		1.83	
Moisture Content Determination									
Container Code		W11	G3T3	O2-2	J41	P3	T1	P15	O2-1
Weight of cont. + wet soil	gram	142	147.2	114	120	122.7	139.6	126	158.5
Weight of cont. + dry soil	gram	122	125.5	95.2	102	102.2	115.6	101	125.4
Weight of water	gram	20	21.69	18.6	18.6	20.51	23.94	25.7	33.13
Weight of container	gram	40.8	37.89	28.3	32.7	35.97	37.65	25.4	28.73
Weight of Dry soil	gram	81.4	87.63	66.9	69	66.26	77.96	75.3	96.65
Dry Density and Moisture Content Determination									
Moisture content	%	24.51	24.75	27.85	26.95	30.95	30.71	34.15	34.28
Avarege Moisture content	%	24.63		27.40		30.83		34.22	
Dry Density	gr/cc	1.37		1.52		1.47		1.36	
Maximum Dry Density	gr/cc	**1.52**							
Optimum Moisture Content	%	**27.6**							



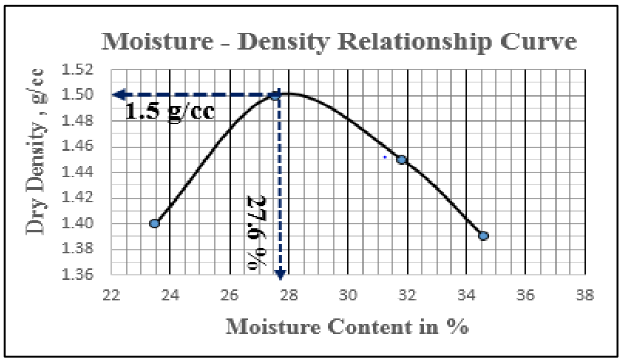
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Seka Town Municipality Office					Test Pit		5 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10143.8		10509.7		10438.3		10278.2	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3634.9		4110.5		4039.1		3879	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.71		1.94		1.90		1.83	
Moisture Content Determination									
Container Code		P3	G	65	G19	C	UC	O3-2	P-3
Weight of cont. + wet soil	gram	122	116.8	191	199	112.06	92.28	163	140.6
Weight of cont. + dry soil	gram	102	100.6	156	161	92.16	73.37	131	110.4
Weight of water	gram	20.3	16.26	35.21	37.5	19.9	18.91	31.85	30.19
Weight of container	gram	25.2	37.91	37.5	34.2	32.86	16.72	41.3	25.98
Weight of Dry soil	gram	76.4	62.65	118	127	59.3	56.65	90.2	84.42
Dry Density and Moisture Content Determination									
Moisture content	%	26.55	25.95	29.73	29.52	33.56	33.38	35.32	35.76
Avarege Moisture content	%	26.25		29.62		33.47		35.54	
Dry Density	gr/cc	1.36		1.49		1.42		1.35	
Maximum Dry Density	gr/cc	**1.49**							
Optimum Moisture Content	%	**29.7**							



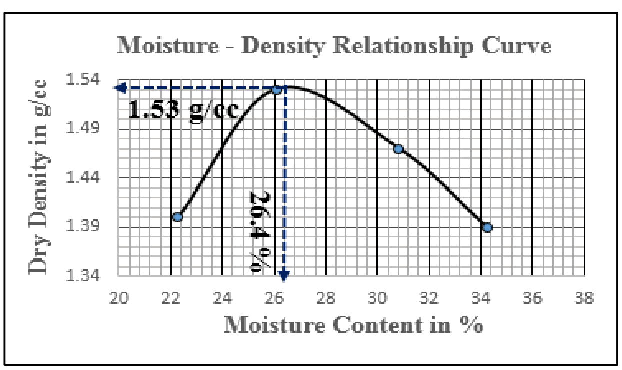
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka High School					Test Pit		6 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10245.4		10547.7		10544.6		10496.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3846.2		4148.5		4145.4		4097.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.81		1.95		1.95		1.93	
Moisture Content Determination									
Container Code		G19	J41	A-13	T2	P66	G	2	P15
Weight of cont. + wet soil	gram	89.8	138.5	205	221	198.7	175.6	183	248.8
Weight of cont. + dry soil	gram	73.6	114.7	163	175	155.7	137.1	142	188.4
Weight of water	gram	16.2	23.87	41.9	45.8	43.02	38.58	41.1	60.42
Weight of container	gram	17.8	32.74	36.6	38.4	37.45	32.39	34.6	33.56
Weight of Dry soil	gram	55.8	81.91	126	137	118.2	104.7	108	154.8
Dry Density and Moisture Content Determination									
Moisture content	%	29.02	29.14	33.19	33.46	36.39	36.86	38.21	39.03
Avarege Moisture content	%	29.08		33.32		36.62		38.62	
Dry Density	gr/cc	1.40		1.46		1.43		1.39	
Maximum Dry Density	gr/cc	1.46							
Optimum Moisture Content	%	33.5							



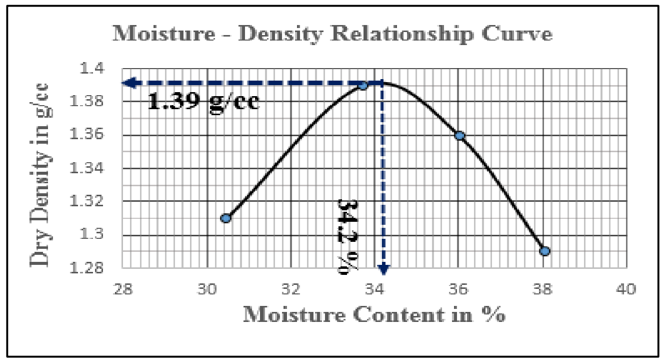
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Seka High School					Test Pit		6 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10175.1		10475.7		10465.5		10373.3	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3666.2		4076.5		4066.3		3974.1	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.73		1.92		1.91		1.87	
Moisture Content Determination									
Container Code		P15	O2-2	14	UC	HC11	C	G19	65
Weight of cont. + wet soil	gram	135	126.7	152	122	129.94	201.2	164	250.5
Weight of cont. + dry soil	gram	114	108.1	123	99.7	102.9	160.5	130	195.6
Weight of water	gram	20.9	18.6	29.2	22.8	27.04	40.72	33.11	54.94
Weight of container	gram	25.4	28.74	17.5	16.7	17.67	32.86	34.3	37.51
Weight of Dry soil	gram	88.7	79.32	106	83	85.23	127.7	96.2	158.1
Dry Density and Moisture Content Determination									
Moisture content	%	23.51	23.45	27.64	27.45	31.73	31.90	34.43	34.76
Avarege Moisture content	%	23.48		27.54		31.81		34.59	
Dry Density	gr/cc	1.40		1.50		1.45		1.39	
Maximum Dry Density	gr/cc	1.50							
Optimum Moisture Content	%	27.6							



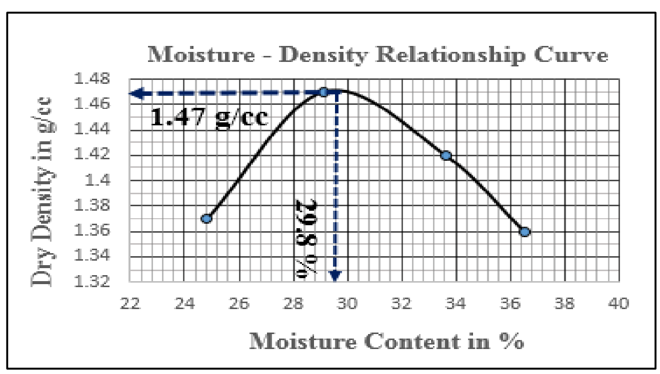
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka High School					Test Pit		6 @ 3m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10047.3		10509.4		10482.3		10363.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3648.1		4110.2		4083.1		3964.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.72		1.94		1.92		1.87	
Moisture Content Determination									
Container Code		P15	P66	ZE	2	A-1C	G	T2	F
Weight of cont. + wet soil	gram	163	211.1	119	147	243.2	197.7	137	146.1
Weight of cont. + dry soil	gram	140	179.4	101	124	197.5	158.9	112	118.2
Weight of water	gram	23.6	31.74	17.8	23.3	45.74	38.87	25.3	27.91
Weight of container	gram	33.6	37.46	33.1	34.6	49.75	32.15	38.4	36.41
Weight of Dry soil	gram	106	141.9	68.1	89.4	147.8	126.7	73.6	81.79
Dry Density and Moisture Content Determination									
Moisture content	%	22.18	22.37	26.06	26.10	30.96	30.68	34.33	34.12
Avarege Moisture content	%	22.27		26.08		30.82		34.23	
Dry Density	gr/cc	1.40		1.53		1.47		1.39	
Maximum Dry Density	gr/cc	**1.53**							
Optimum Moisture Content	%	**26.4**							



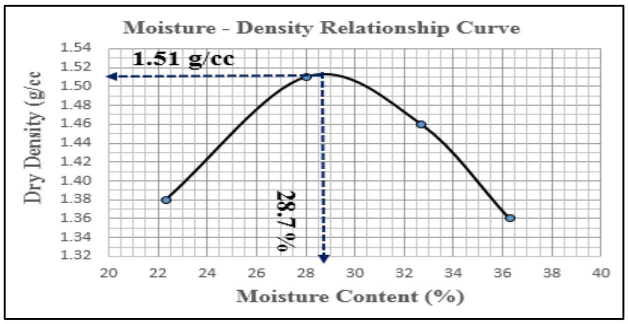
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	New Generation KG School					Test Pit		7 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10041.5		10360.7		10334.6		10194.3	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3642.3		3961.5		3935.4		3795.1	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.71		1.87		1.85		1.79	
Moisture Content Determination									
Container Code		10G	47	G19	W11	C13T2	T2	B1	O4-3
Weight of cont. + wet soil	gram	102	90.69	134	145	139.87	100.6	100	102
Weight of cont. + dry soil	gram	82	73.5	109	119	112.1	78.59	77.6	78.75
Weight of water	gram	19.6	17.19	25.1	26.4	27.78	21.97	22.6	23.26
Weight of container	gram	17.7	17.07	34.3	40.8	34.95	17.58	18.2	17.7
Weight of Dry soil	gram	64.3	56.43	74.5	78.2	77.14	61.01	59.3	61.05
Dry Density and Moisture Content Determination									
Moisture content	%	30.48	30.46	33.67	33.76	36.01	36.01	38.03	38.10
Avarege Moisture content	%	30.47		33.71		36.01		38.07	
Dry Density	gr/cc	1.31		1.39		1.36		1.29	
Maximum Dry Density	gr/cg	**1.39**							
Optimum Moisture Content	%	**34.2**							



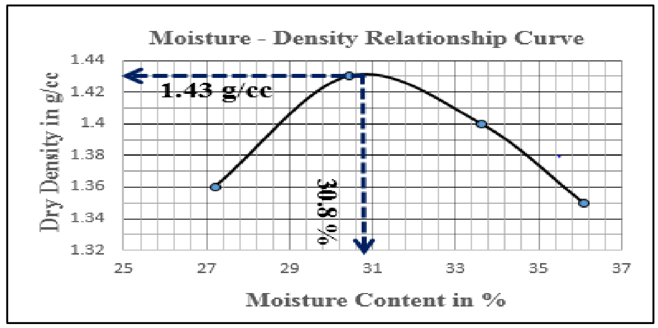
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	New Generation KG School					Test Pit		7 @ 2m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10038.4		10444.2		10428.8		10399.1	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3639.2		4045		4029.6		3999.9	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.71		1.90		1.90		1.88	
Moisture Content Determination									
Container Code		A-13	O3-1	M	P65	ZE	CS3	P66	P6
Weight of cont. + wet soil	gram	109	104.7	120	127	134.70	150.9	131	157.8
Weight of cont. + dry soil	gram	94.8	91.27	102	107	109.2	121.1	105	124.2
Weight of water	gram	14.5	13.46	18.1	20.1	25.48	29.8	25.9	33.62
Weight of container	gram	36.6	36.71	40.2	37.8	33.08	32.88	37.5	37.7
Weight of Dry soil	gram	58.3	54.56	62	68.8	76.14	88.22	67.8	86.51
Dry Density and Moisture Content Determination									
Moisture content	%	24.96	24.67	29.11	29.15	33.46	33.78	38.19	38.86
Avarege Moisture content	%	24.81		29.13		33.62		38.53	
Dry Density	gr/cc	1.37		1.47		1.42		1.36	
Maximum Dry Density	gr/cc	**1.47**							
Optimum Moisture Content	%	**29.8**							



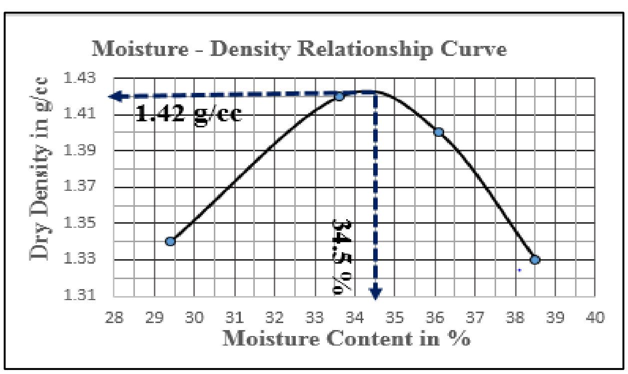
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	New Generation KG School					Test Pit		7 @ 3m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10108.1		10519.3		10501.3		10336.7	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3599.2		4120.1		4102.1		3937.5	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.69		1.94		1.93		1.85	
Moisture Content Determination									
Container Code		O3-5	A	O3-3	O5-1	O6-2	NB	29	O2-3
Weight of cont. + wet soil	gram	138	171.6	82.6	91	126.48	114.6	85.1	107
Weight of cont. + dry soil	gram	116	146.6	68.4	74.8	99.2	91.05	67.3	83.38
Weight of water	gram	22.4	25	14.2	16.2	27.28	23.59	17.83	23.58
Weight of container	gram	17.6	37.71	17.5	17.5	17.15	17.59	17.6	17.65
Weight of Dry soil	gram	97.9	108.8	50.9	57.3	82.05	73.46	49.7	65.73
Dry Density and Moisture Content Determination									
Moisture content	%	22.89	22.97	27.88	28.21	33.25	32.11	35.88	35.87
Avarege Moisture content	%	22.93		28.04		32.68		35.87	
Dry Density	gr/cc	1.38		1.51		1.46		1.36	
Maximum Dry Density	gr/cc	**1.51**							
Optimum Moisture Content	%	**28.7**							



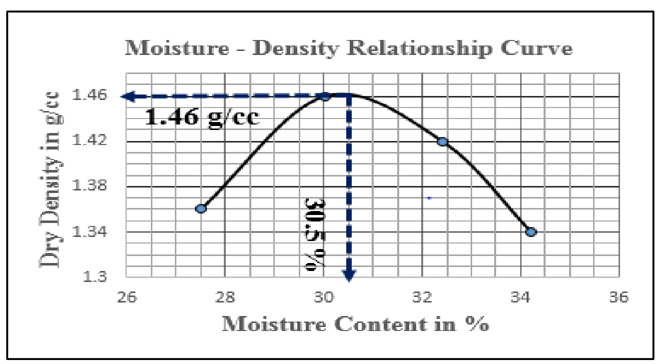
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Hospital					Test Pit		8 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10084.8		10374.7		10358.5		10310.9	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3685.6		3975.5		3959.3		3911.7	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.74		1.87		1.86		1.84	
Moisture Content Determination									
Container Code		14	P15	O2-2	HC11	C3	T2	P2	SG=3
Weight of cont. + wet soil	gram	89	106	115	104	123.4	99.85	92.4	139.82
Weight of cont. + dry soil	gram	73.7	88.78	94.5	83.8	98.99	79.25	72.6	109.44
Weight of water	gram	15.3	17.25	20.1	20	24.45	20.6	19.79	30.38
Weight of container	gram	17.5	25.42	28.7	17.7	26.75	17.58	17.7	25.4
Weight of Dry soil	gram	56.3	63.36	65.7	66.1	72.24	61.67	54.9	84.04
Dry Density and Moisture Content Determination									
Moisture content	%	27.17	27.23	30.59	30.29	33.85	33.40	36.02	36.15
Avarege Moisture content	%	27.20		30.44		33.62		36.09	
Dry Density	gr/cc	1.36		1.43		1.40		1.35	
Maximum Dry Density	gr/cc	**1.43**							
Optimum Moisture Content	%	**30.8**							



Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Hospital					Test Pit		8 @ 1 m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10095.6		10442.3		10431.2		10324.6	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3696.4		4043.1		4032		3925.4	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.74		1.90		1.90		1.85	
Moisture Content Determination									
Container Code		B1	T2	O2-3	GS3	1A	D	A-1C	9
Weight of cont. + wet soil	gram	68	133.6	119	130	113.5	148.6	174	165.20
Weight of cont. + dry soil	gram	56.8	107.0	93.3	102	88.12	117.01	140	128.00
Weight of water	gram	11.2	26.57	25.6	28.1	25.37	31.56	34.30	37.20
Weight of container	gram	18.2	17.57	17.7	17.5	17.73	29.58	49.7	32.39
Weight of Dry soil	gram	38.6	89.47	75.6	84.3	70.39	87.43	90.2	95.61
Dry Density and Moisture Content Determination									
Moisture content	%	29.10	29.70	33.85	33.33	36.04	36.10	38.01	38.91
Avarege Moisture content	%	29.4		33.6		36.1		38.5	
Dry Density	gr/cc	1.34		1.42		1.40		1.33	
Maximum Dry Density	gr/cc	**1.42**							
Optimum Moisture Content	%	**34.5**							

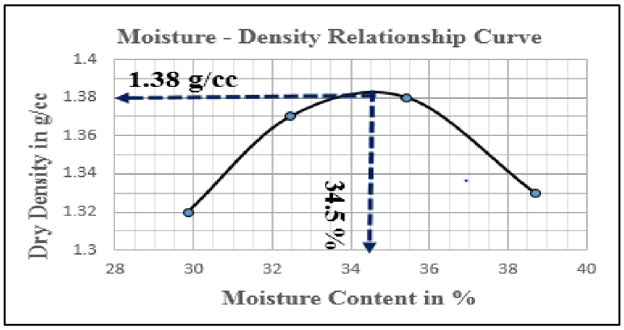


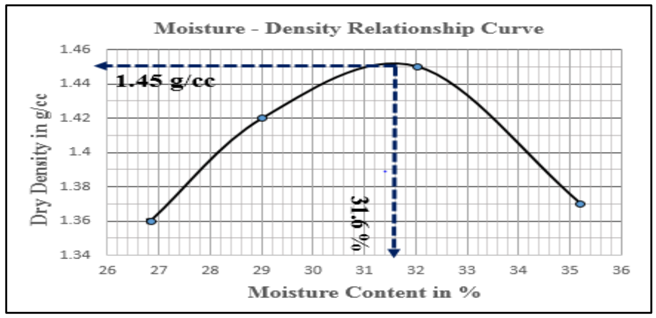
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Hospital					Test Pit		8 @ 3m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10090.6		10443.7		10393.6		10228.7	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3691.4		4044.5		3994.4		3829.5	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.74		1.90		1.88		1.80	
Moisture Content Determination									
Container Code		HC11	G19	5	RG	O6-3	O5-2	O6-12	O6-16
Weight of cont. + wet soil	gram	116	233.3	154	205	88.12	91.3	92.2	107.26
Weight of cont. + dry soil	gram	95.2	191.1	124	164	70.89	73.19	73	84.68
Weight of water	gram	21.3	42.2	29.6	41.5	17.23	18.11	19.24	22.58
Weight of container	gram	17.7	37.93	26	25.2	17.17	17.91	17.4	17.93
Weight of Dry soil	gram	77.5	153.2	98.4	139	53.72	55.28	55.6	66.75
Dry Density and Moisture Content Determination									
Moisture content	%	27.42	27.55	30.10	29.94	32.07	32.76	34.60	33.83
Avarege Moisture content	%	27.49		30.02		32.42		34.22	
Dry Density	gr/cc	1.36		1.46		1.42		1.34	
Maximum Dry Density	gr/cc	**1.46**							
Optimum Moisture Content	%	**30.5**							



Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Preparatory School					Test Pit		9 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10052.4		10267.7		10380.6		10320.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3653.2		3868.5		3981.4		3921.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.72		1.82		1.87		1.85	
Moisture Content Determination									
Container Code		G19	J41	A-13	T2	P66	G	2	P15
Weight of cont. + wet soil	gram	91.8	141.2	205	222	197.5	174.3	185	245.89
Weight of cont. + dry soil	gram	74.8	116.3	164	177	155.7	137.1	143	186.24
Weight of water	gram	17	24.96	41.5	44.8	41.74	37.2	41.6	59.65
Weight of container	gram	17.8	32.74	36.6	38.4	37.45	32.39	34.6	33.56
Weight of Dry soil	gram	57	83.51	127	138	118.3	104.7	109	152.68
Dry Density and Moisture Content Determination									
Moisture content	%	29.83	29.89	32.58	32.37	35.29	35.54	38.28	39.07
Avarege Moisture content	%	29.86		32.47		35.42		38.68	
Dry Density	gr/cc	1.32		1.37		1.38		1.33	
Maximum Dry Density	gr/cc	**1.38**							
Optimum Moisture Content	%	**34.5**							

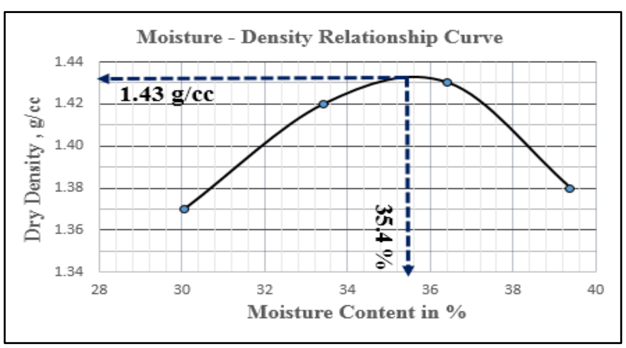
Test	MODIFIED AASHTO COMPACTION TEST (AASHTO T-180)								
Site	Seka Preparatory School					Test Pit		9 @ 3m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10073.3		10302.4		10470.3		10347.5	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3674.1		3903.2		4071.1		3948.3	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.73		1.84		1.92		1.86	
Moisture Content Determination									
Container Code		P15	P66	ZE	2	A-1C	G	T2	F
Weight of cont. + wet soil	gram	160	205.9	114	144	232.8	190.4	131	140.22
Weight of cont. + dry soil	gram	133	170.3	95.9	119	188.5	152	107	113.2
Weight of water	gram	26.7	35.61	18.2	24.5	44.33	38.45	24.2	27.02
Weight of container	gram	33.6	37.46	33.1	34.6	49.75	32.15	38.4	36.41
Weight of Dry soil	gram	99.4	132.8	62.8	84.4	138.8	119.8	68.6	76.79
Dry Density and Moisture Content Determination									
Moisture content	%	26.87	26.81	28.96	29.07	31.95	32.09	35.23	35.19
Avarege Moisture content	%	26.84		29.02		32.02		35.21	
Dry Density	gr/cc	1.36		1.42		1.45		1.37	
Maximum Dry Density	gr/cc	**1.45**							
Optimum Moisture Content	%	**31.6**							

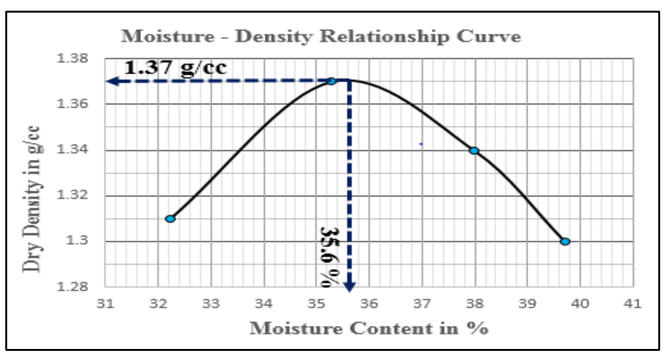




Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Seka Preparatory School					Test Pit		9 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10281.1		10437.4		10545.5		10490.3	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3772.2		4038.2		4146.3		4091.1	
Volume of Mold	cu.cm	2124							
Wet Density	gr/cu.cm	1.78		1.90		1.95		1.93	
Moisture Content Determination									
Container Code		P15	O2-2	14	UC	HC11	C	G19	65
Weight of cont. + wet soil	gram	136	127.9	153	122	128.34	201.8	164	253.48
Weight of cont. + dry soil	gram	110	105.1	119	95.7	98.9	156.5	127	192.58
Weight of water	gram	25.6	22.86	34.2	26.2	29.44	45.25	36.79	60.9
Weight of container	gram	25.4	28.74	17.5	16.7	17.67	32.86	34.3	37.51
Weight of Dry soil	gram	84.7	76.32	102	79	81.23	123.7	93.2	155.07
Dry Density and Moisture Content Determination									
Moisture content	%	30.17	29.95	33.71	33.13	36.24	36.59	39.49	39.27
Avarege Moisture content	%	30.06		33.42		36.42		39.38	
Dry Density	gr/cu.cm	1.37		1.42		1.43		1.38	
Maximum Dry Density	gr/cu.cm	**1.43**							
Optimum Moisture Content	%	**35.4**							

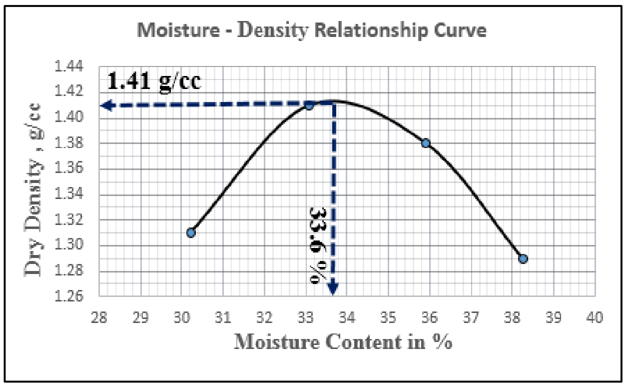
Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Lideta Orthodox Church					Test Pit		10 @ 1m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10053.4		10344.2		10335.8		10301.1	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3654.2		3945		3936.6		3901.9	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.72		1.86		1.85		1.84	
Moisture Content Determination									
Container Code		A-13	O3-1	M	P65	ZE	CS3	P66	P6
Weight of cont. + wet soil	gram	109	106.6	122	128	133.87	153.4	129	154.86
Weight of cont. + dry soil	gram	91.8	89.97	101	105	106.2	120.1	103	121.51
Weight of water	gram	17.3	16.6	21.3	23.6	27.67	33.25	25.9	33.35
Weight of container	gram	36.6	36.71	40.2	37.8	33.08	32.88	37.5	37.7
Weight of Dry soil	gram	55.3	53.26	60.6	66.8	73.12	87.22	65.3	83.81
Dry Density and Moisture Content Determination									
Moisture content	%	31.29	31.17	35.08	35.29	37.84	38.12	39.62	39.79
Avarege Moisture content	%	31.23		35.19		37.98		39.71	
Dry Density	gr/cc	1.31		1.37		1.34		1.31	
Maximum Dry Density	gr/cc	**1.37**							
Optimum Moisture Content	%	**35.6**							

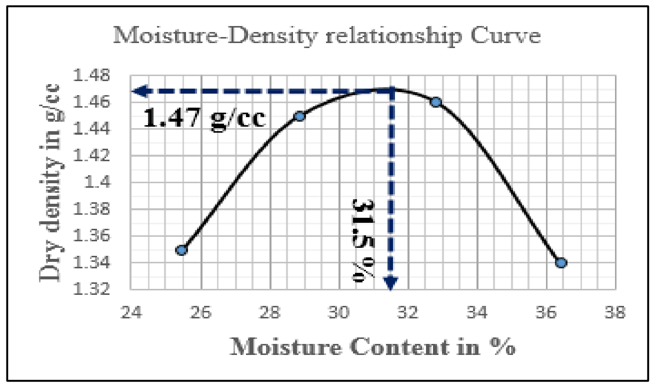




Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Lideta Orthodox Church					Test Pit		10 @ 2m	
Wet Density Determination									
	Unit								
Trial Number		1		2		3		4	
Weight of Mold + wet soil	gram	10130.1		10397.3		10378.3		10188	
Weight of Mold	gram	6508.9							
Weight of Wet soil	gram	3621.2		3998.1		3979.1		3788.8	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.70		1.88		1.87		1.78	
Moisture Content Determination									
Container Code		O3-5	A	O3-3	O5-1	O6-2	NB	29	O2-3
Weight of cont. + wet soil	gram	137	171.6	81.6	89.7	116.48	113.3	83.9	104.52
Weight of cont. + dry soil	gram	110	140.6	65.7	71.7	90.2	88.05	65.7	80.38
Weight of water	gram	27.8	31.01	15.9	18	26.28	25.27	18.29	24.14
Weight of container	gram	17.6	37.71	17.5	17.5	17.15	17.59	17.6	17.65
Weight of Dry soil	gram	91.9	102.8	48.2	54.2	73.05	70.46	48.1	62.73
Dry Density and Moisture Content Determination									
Moisture content	%	30.26	30.15	33.07	33.10	35.98	35.86	38.02	38.48
Avarege Moisture content	%	30.21		33.09		35.92		38.25	
Dry Density	gr/cc	1.31		1.41		1.38		1.29	
Maximum Dry Density	gr/cc	**1.41**							
Optimum Moisture Content	%	**33.6**							

Test	MODIFIED COMPACTION TEST (AASHTO T-180)								
Site	Lideta Orthodox Church					Test Pit		10 @ 3m	
Wet Density Determination									
	Unit								
Trial		1		2		3		4	
Weight of Mold + wet soil	gram	10070.5		10355.7		10529.6		10365.3	
Weight of Mold	gram	6399.2							
Weight of Wet soil	gram	3671.3		3956.5		4130.4		3966.1	
Volume of Mold	cc	2124							
Wet Density	gr/cc	1.73		1.86		1.94		1.87	
Moisture Content Determination									
Container Code		10G	47	G19	W11	C13T2	T2	B1	O4-3
Weight of cont. + wet soil	gram	102	91.46	134	145	139.95	105.3	101	103.95
Weight of cont. + dry soil	gram	85	76.61	112	122	114.2	83.84	78.9	80.55
Weight of water	gram	16.8	14.85	22	22.9	25.76	21.43	22.4	23.4
Weight of container	gram	17.7	17.07	34.3	40.8	34.95	17.58	18.2	17.7
Weight of Dry soil	gram	67.3	59.54	77.5	81.2	79.24	66.26	60.6	62.85
Dry Density and Moisture Content Determination									
Moisture content	%	24.99	24.94	28.38	28.14	32.51	32.34	37.00	37.23
Avarege Moisture content	%	24.96		28.26		32.43		37.12	
Dry Density	gr/cc	1.38		1.45		1.47		1.36	
Maximum Dry Density	gr/cc	**1.47**							
Optimum Moisture Content	%	**31.5**							





Appendix N

California Bearing Ratio (CBR) Laboratory Analysis and Test result of all Samples

Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)						
Site	Agricultural Office					Test Pit	TP1 @ 1m
Wet Density Determination							
	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6524.9		6629.7		6452.9	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows per Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	10147	10398.7	10435.8	10596.6	10404.3	10588.1
Weight of Wet soil	gram	3622.1	3873.8	3806.1	3966.9	3951.4	4135.2
Wet Density	g/cc	1.71	1.82	1.79	1.87	1.86	1.95

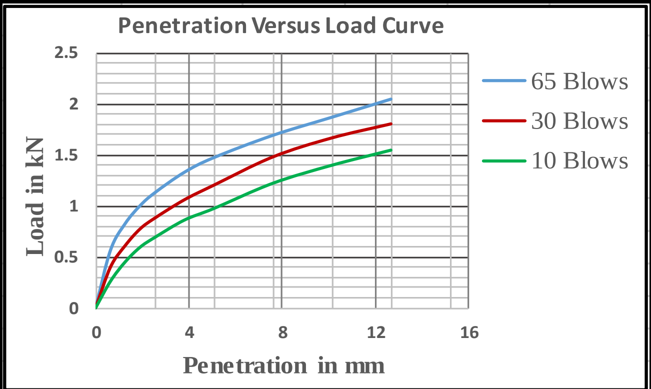
Moisture Content and Dry Density Determination													
Container Code		G-56	SR	P10	O1-3	M	S-2	O6-1	O6-12	G-19	N	13	SB
Weight of cont. + wet soil	gram	78.2	85.0	107.0	96.3	123.3	85.4	93.7	99.5	81.8	85.1	93.9	116.9
Weight of cont. + dry soil	gram	65.9	70.9	82.5	74.3	103.8	69.9	73.2	77.3	67.0	69.1	73.6	90.1
Weight of water	gram	12.3	14.1	24.5	22.1	19.4	15.5	20.6	22.2	14.8	16.0	20.3	26.8
Weight of container	gram	25.2	25.3	17.5	17.5	40.2	17.9	17.5	17.4	17.8	16.8	18.2	18.4
Weight of Dry soil	gram	40.7	45.7	65.0	56.7	63.6	52.0	55.7	59.9	49.2	52.3	55.4	71.7
Moisture content	%	30.4	30.9	37.7	38.9	30.6	29.8	36.9	37.0	30.1	30.6	36.6	37.4
Avarege Moisture content	%	30.61		38.32		30.19		36.94		30.35		36.98	
Dry Density	g/cc	1.31		1.32		1.38		1.36		1.43		1.42	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.261	0.401	0.563
1.27	0.45	0.611	0.823
1.91	0.594	0.775	0.998
2.54	**0.69**	**0.881**	**1.124**
3.81	0.86	1.061	1.324
5.08	**0.974**	**1.205**	**1.468**
7.62	1.222	1.483	1.686
10.16	1.399	1.67	1.863
12.7	1.547	1.808	2.04

Plot of Penetration Versus Load Curve

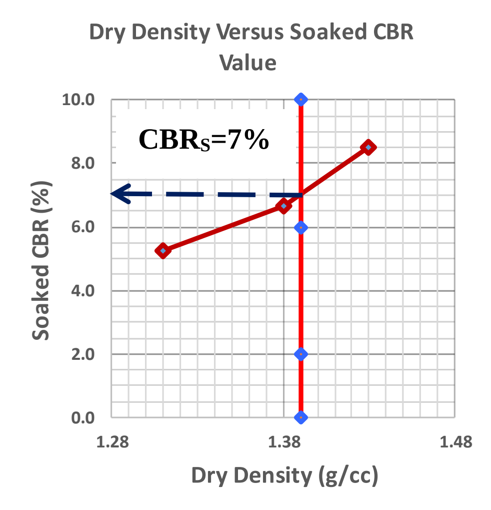


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.31	1.38	1.43
Specimen Load @ 2.54 mm	kN	0.69	0.881	1.124
Specimen Load @ 5.08 mm	kN	0.97	1.205	1.468
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	5.2	6.7	8.5
Soaked CBR value @ 5.08	%	4.9	6.0	7.3
Larger Soaked CBR Value	%	5.2	6.7	8.5
Data from Modified Compaction Proctor Test				
OMC	%	32.7		
MDD	g/cc	1.46		
Density required	%	95		
Target Density required	g/cc	1.39		
CBR Value at Target Density	%	**7.0**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Agricultural Office	Test Pit	TP1 @ 2m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6508.6		6552.1		6436	
Volume of Mold	cc	2124		2124		2060.214	
Number of Layer		5		5		5	
Number of Blows per Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9726.2	10210.7	10291.1	10430.1	10489.4	10618.8
Weight of Wet soil	gram	3217.6	3702.1	3739	3878	4053.4	4182.8
Wet Density	g/cc	1.51	1.74	1.76	1.83	1.91	1.97

Moisture Content and Dry Density Determination

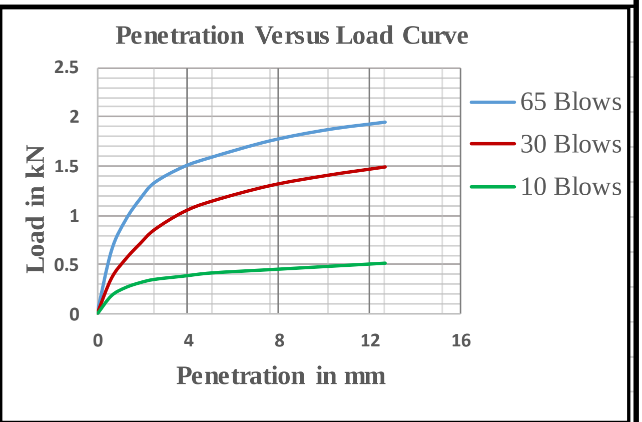
Container Code		S-3	P65	P2	O6-11	T1	P6	O6-3	14	O2-3	14	AT	G-21
Weight of cont. + wet soil	gram	103.07	154.36	101.12	93.51	152.84	144.38	92.83	102.64	98.44	95.12	94.58	102.93
Weight of cont. + dry soil	gram	83.55	128.52	77.19	70.75	124.35	117.80	72.47	79.91	78.91	76.39	73.89	80.37
Weight of water	gram	19.52	25.84	23.93	22.75	28.49	26.58	20.37	22.73	19.53	18.74	20.70	22.55
Weight of container	gram	17.59	37.82	17.66	17.93	31.64	31.72	17.15	17.42	17.67	17.53	17.55	17.98
Weight of Dry soil	gram	65.96	90.70	59.53	52.82	92.71	86.08	55.32	62.49	61.24	58.86	56.33	62.40
Moisture content	%	29.59	28.49	40.20	43.08	30.73	30.88	36.82	36.38	31.89	31.83	36.74	36.14
Avarege Moisture content	%	29.04		41.64		30.80		36.60		31.86		36.44	
Dry Density	g/cc	1.17		1.23		1.35		1.34		1.45		1.44	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.191	0.366	0.641
1.27	0.275	0.563	0.954
1.91	0.325	0.721	1.167
2.54	**0.358**	**0.861**	**1.33**
3.81	0.391	1.04	1.489
5.08	**0.424**	**1.151**	**1.588**
7.62	0.457	1.307	1.751
10.16	0.49	1.412	1.864
12.7	0.523	1.497	1.94

Plot of Penetration Versus Load Curve

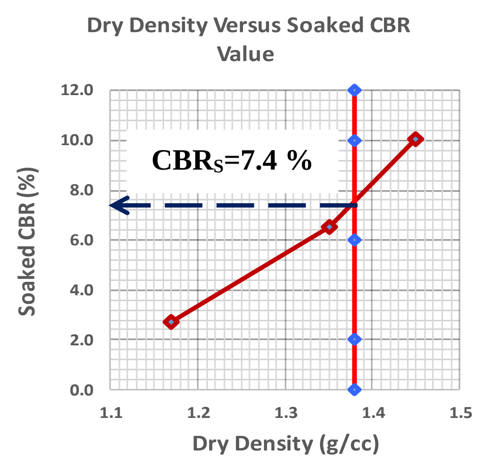


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.17	1.35	1.45
Specimen Load @ 2.54 mm	kN	0.358	0.861	1.33
Specimen Load @ 5.08 mm	kN	0.424	1.151	1.588
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.7	6.5	10.1
Soaked CBR value @ 5.08	%	2.1	5.8	7.9
Larger Soaked CBR Value	%	2.7	6.5	10.1
Data from Modified Compaction Proctor Test				
OMC	%	32.5		
MDD	g/cc	1.45		
Density required	%	95		
Target Density required	g/cc	1.38		
CBR Value at Target Density	%	7.4		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)						
Site	Agricultural Office				Test Pit		TP1 @ 3m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6504.3		6628.6		6533.1	
Volume of Mold	cc	2124		2124		2060.214	
Number of Layer		5		5		5	
Number of Blows per Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	10060.9	10422.6	10641.6	10876.3	10662.4	10828.5
Weight of Wet soil	gram	3556.6	3918.3	4013	4247.7	4129.3	4295.4
Wet Density	g/cc	1.67	1.84	1.89	2.00	1.94	2.02

Moisture Content and Dry Density Determination

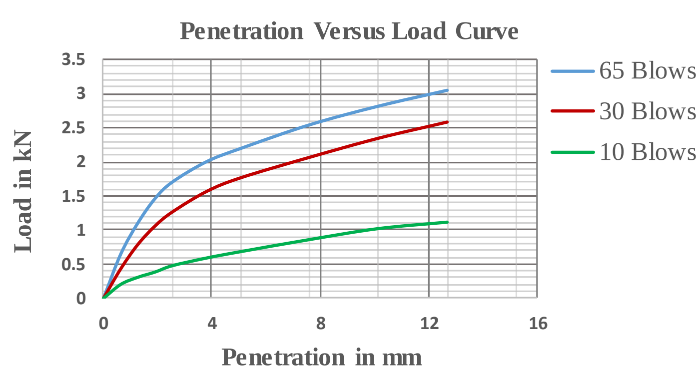
Container Code		ZE	A16	T1	G3T3	C3	P2	D	E	P10	NB	12	N
Weight of cont. + wet soil	gram	144.48	147.64	154.77	141.12	109.02	121.51	137.53	147.13	93.45	92.58	108.54	111.50
Weight of cont. + dry soil	gram	118.90	121.30	119.21	109.22	90.63	98.67	107.25	111.66	76.74	76.18	87.21	86.62
Weight of water	gram	25.58	26.34	35.56	31.91	18.39	22.85	30.29	35.47	16.71	16.40	21.33	24.87
Weight of container	gram	33.08	32.86	37.65	37.93	26.73	17.65	27.22	18.25	17.55	17.60	28.14	18.19
Weight of Dry soil	gram	85.82	88.44	81.56	71.29	63.90	81.01	80.02	93.41	59.19	58.58	59.07	68.43
Moisture content	%	29.80	29.79	43.60	44.75	28.78	28.20	37.85	37.98	28.23	28.00	36.10	36.35
Avarege Moisture content	%	29.80		44.17		28.49		37.91		28.12		36.23	
Dry Density	g/cc	1.29		1.28		1.47		1.45		1.52		1.48	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.207	0.432	0.649
1.27	0.312	0.786	1.103
1.91	0.39	1.058	1.463
2.54	**0.483**	**1.26**	**1.702**
3.81	0.597	1.561	2.002
5.08	**0.692**	**1.762**	**2.197**
7.62	0.87	2.06	2.542
10.16	1.032	2.338	2.815
12.7	1.127	2.574	3.047

Plot of Penetration Versus Load Curve

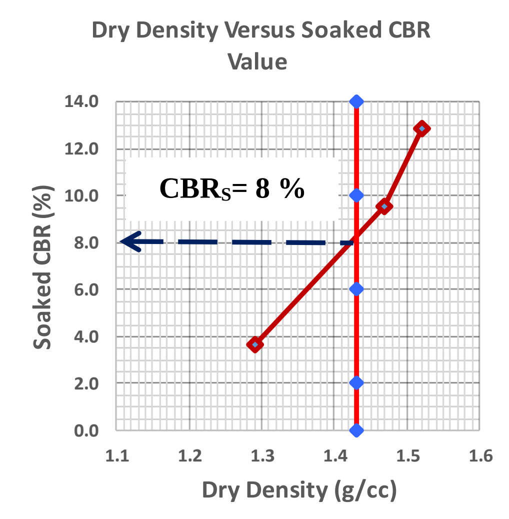


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.29	1.47	1.52
Specimen Load @ 2.54 mm	kN	0.483	1.26	1.702
Specimen Load @ 5.08 mm	kN	0.692	1.762	2.197
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	3.7	9.5	12.9
Soaked CBR value @ 5.08	%	3.5	8.8	11.0
Larger Soaked CBR Value	%	3.7	9.5	12.9
Data from Modified Compaction Proctor Test				
OMC	%	28.8		
MDD	g/cc	1.5		
Density required	%	95		
Target Density required	g/cc	1.43		
CBR Value at Target Density	%	**8.0**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Seka Town Bus Station	Test Pit	TP2 @ 1m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6608		6598		6476.5	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows per Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9958.4	10358.9	10322.5	10567.8	10660.9	10871.8
Weight of Wet soil	gram	3350.4	3750.9	3724.5	3969.8	4184.4	4395.3
Wet Density	g/cc	1.58	1.77	1.75	1.87	1.97	2.07

Moisture Content and Dry Density Determination

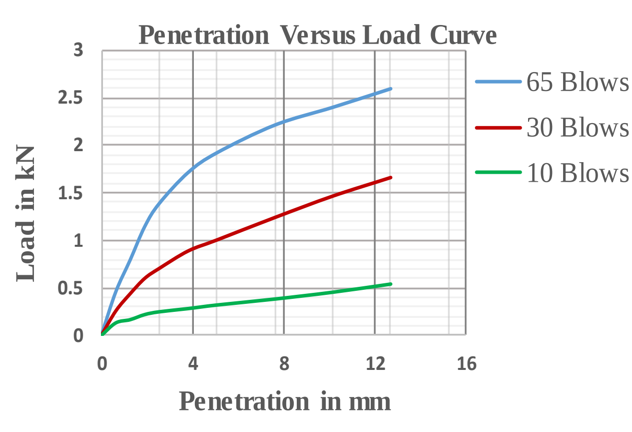
Container Code		O4-2	O4-1	10G	B3	MK	G	O1-3	G7	O6-1	P1	K-4	T1C1
Weight of cont. + wet soil	gram	88.86	84.88	91.26	83.15	73.26	89.86	114.50	99.98	56.71	47.18	115.94	103.81
Weight of cont. + dry soil	gram	73.11	70.01	69.11	63.31	60.94	73.88	87.20	76.64	48.11	40.68	89.46	81.03
Weight of water	gram	15.75	14.87	22.16	19.84	12.32	15.97	27.30	23.34	8.60	6.50	26.48	22.78
Weight of container	gram	17.67	17.62	17.72	17.38	17.64	17.71	17.55	17.39	17.47	17.89	17.93	17.72
Weight of Dry soil	gram	55.44	52.39	51.39	45.93	43.30	56.17	69.66	59.25	30.64	22.79	71.53	63.31
Moisture content	%	28.41	28.39	43.11	43.21	28.46	28.44	39.19	39.39	28.07	28.53	37.01	35.98
Avarege Moisture content	%	28.40		43.16		28.45		39.29		28.30		36.49	
Dry Density	g/cc	1.23		1.23		1.37		1.34		1.54		1.52	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.134	0.258	0.463
1.27	0.168	0.438	0.798
1.91	0.222	0.599	1.151
2.54	**0.251**	**0.702**	**1.392**
3.81	0.285	0.885	1.72
5.08	**0.323**	**1.001**	**1.929**
7.62	0.386	1.236	2.221
10.16	0.458	1.46	2.408
12.7	0.544	1.654	2.604

Plot of Penetration Versus Load Curve



Summary of CBR Value from the CBR Test Software

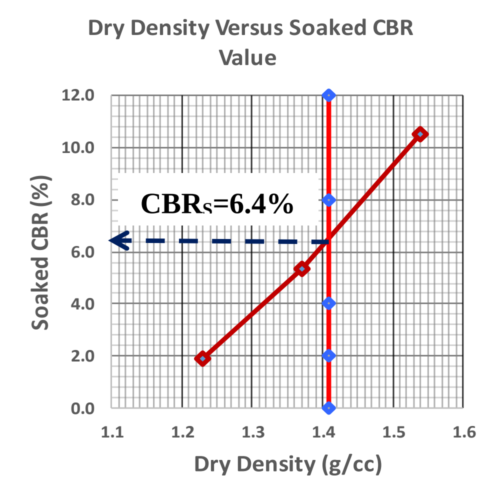
CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.23	1.37	1.54
Specimen Load @ 2.54 mm	kN	0.251	0.702	1.392
Specimen Load @ 5.08 mm	kN	0.323	1.001	1.929
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	1.9	5.3	10.5
Soaked CBR value @ 5.08	%	1.6	5.0	9.6
Larger Soaked CBR Value	%	1.9	5.3	10.5

Data from Modified Compaction Proctor Test

OMC	%	32.3
MDD	g/cc	1.48
Density required	%	95
Target Density required	g/cc	1.41
CBR Value at Target Density	%	**6.4**

Plot of Dry Density Versus Soaked CBR Value



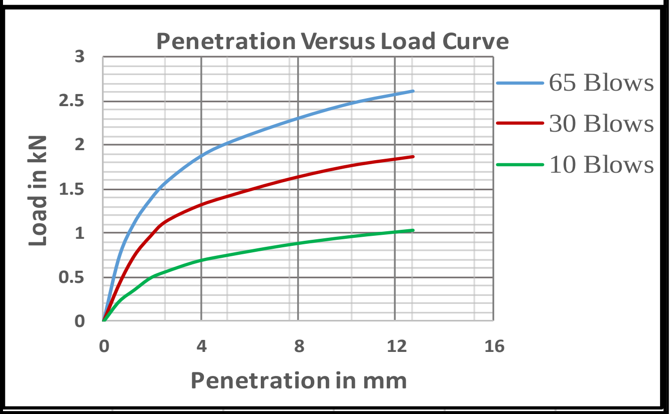
Test	California Bearing Ratkio (CBR) Test, (AASHTO T 193-93)											
Site	Seka Town Bus Station								Test Pit		TP2 @ 2m	
Wet Density Determination												
	Units											
Mold Number		1				2				3		
Mass of Mold	gram	6486.4				6576				6262		
Volume of Mold	cc	2124				2124				2124		
Number of Layer		5				5				5		
Number of Blows per Layer		10				30				65		
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking
Weight of Mold + wet soil	gram	9849.8		10231		10594.7		10762.1		10750.5		10899.3
Weight of Wet soil	gram	3363.4		3744.6		4018.7		4186.1		4488.5		4637.3
Wet Density	g/cc	1.58		1.76		1.89		1.97		2.11		2.18
Moisture Content and Dry Density Determination												
Container Code		RG	P66	O5-2	O2-3	P3	A-13	II	G19	ZE	D	113	P66
Weight of cont. + wet soil	gram	154.3	163.3	98.1	110.6	110.2	106.1	107.8	110.7	122.2	109.5	144.3	145.5
Weight of cont. + dry soil	gram	124.5	134.3	73.7	82.4	93.3	90.1	83.6	85.5	101.7	91.1	115.3	117.2
Weight of water	gram	29.7	29.0	24.4	28.2	16.9	16.0	24.2	25.1	20.5	18.4	29.0	28.4
Weight of container	gram	25.2	37.4	17.9	17.7	36.0	36.6	18.0	17.8	33.1	29.6	37.9	37.4
Weight of Dry soil	gram	99.3	96.9	55.8	64.8	57.3	53.5	65.6	67.7	68.6	61.5	77.4	79.8
Moisture content	%	30.0	30.0	43.7	43.5	29.5	29.9	36.9	37.1	29.8	29.8	37.5	35.5
Avarege Moisture content	%	29.96		43.58		29.73		36.98		29.83		36.50	
Dry Density	g/cc	1.22		1.23		1.46		1.44		1.63		1.60	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	**Specimen Load (kN)**		
	10 blows	**30 blows**	**65 blows**
0	0	0	0
0.64	0.225	0.422	0.736
1.27	0.356	0.745	1.126
1.91	0.486	0.958	1.382
2.54	**0.558**	**1.125**	**1.578**
3.81	0.673	1.295	1.848
5.08	**0.744**	**1.411**	**2.028**
7.62	0.863	1.606	2.279
10.16	0.954	1.758	2.481
12.7	1.025	1.859	2.621

Plot of Penetration Versus Load Curve

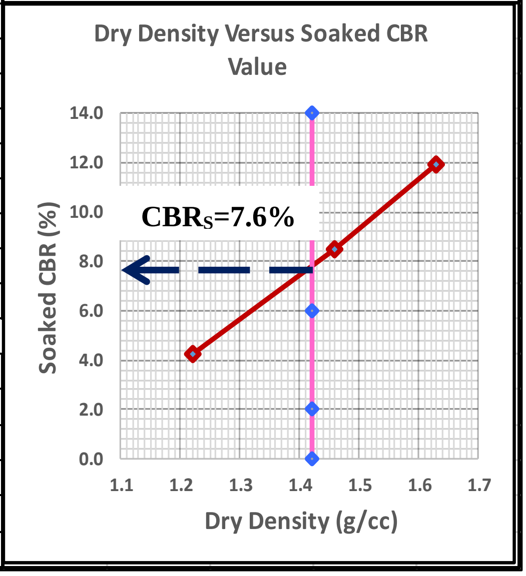


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.22	1.46	1.63
Specimen Load @ 2.54 mm	kN	0.558	1.125	1.578
Specimen Load @ 5.08 mm	kN	0.744	1.411	2.028
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.2	8.5	12.0
Soaked CBR value @ 5.08	%	3.7	7.1	10.1
Larger Soaked CBR Value	%	4.2	8.5	12.0
Data from Modified Compaction Proctor Test				
OMC	%	31.5		
MDD	g/cc	1.49		
Density required	%	95		
Target Density required	g/cc	1.42		
CBR Value at Target Density	%	7.6		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Seka Town Bus Station	Test Pit	TP2 @ 3m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6763		6835.4		6408.6	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows per Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	10113.1	10496.7	10557.2	10742.1	10609	10891.6
Weight of Wet soil	gram	3350.1	3733.7	3721.8	3906.7	4200.4	4483
Wet Density	g/cc	1.58	1.76	1.75	1.84	1.98	2.11

Moisture Content and Dry Density Determination

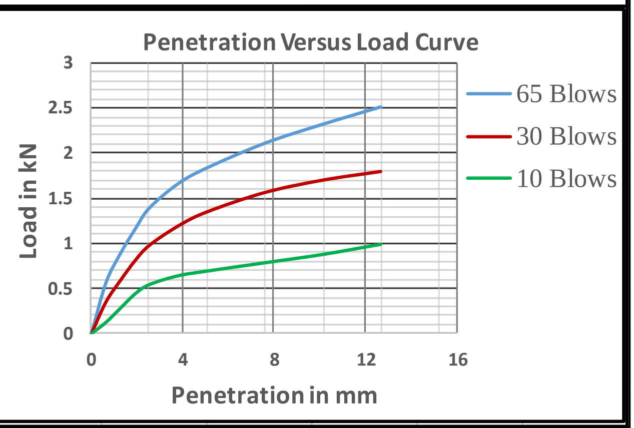
Container Code		P66	A-1C	P2	HC51	MK	P15	AT	II	DH	G	HC12	10G
Weight of cont. + wet soil	gram	117.7	128.8	121.8	122.0	85.2	117.3	113.3	115.6	80.0	93.3	112.0	113.7
Weight of cont. + dry soil	gram	99.9	111.4	92.6	92.8	70.7	99.4	88.7	90.3	66.7	77.2	88.2	88.7
Weight of water	gram	17.8	17.4	29.2	29.2	14.5	17.8	24.6	25.3	13.3	16.1	23.8	25.0
Weight of container	gram	37.5	49.7	17.5	17.7	17.6	33.5	17.6	18.0	17.0	17.9	18.1	17.7
Weight of Dry soil	gram	62.5	61.7	75.1	75.2	53.1	65.9	71.1	72.3	49.7	59.2	70.0	71.0
Moisture content	%	28.5	28.1	38.9	38.8	27.4	27.1	34.6	34.9	26.7	27.2	34.0	35.2
Avarege Moisture content	%	28.30		38.84		27.21		34.77		26.93		34.63	
Dry Density	g/cc	1.23		1.27		1.38		1.36		1.56		1.57	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.126	0.353	0.564
1.27	0.281	0.59	0.883
1.91	0.439	0.809	1.15
2.54	**0.543**	**0.98**	**1.386**
3.81	0.641	1.196	1.656
5.08	**0.693**	**1.353**	**1.831**
7.62	0.785	1.568	2.103
10.16	0.877	1.705	2.312
12.7	0.989	1.801	2.503

Plot of Penetration Versus Load Curve

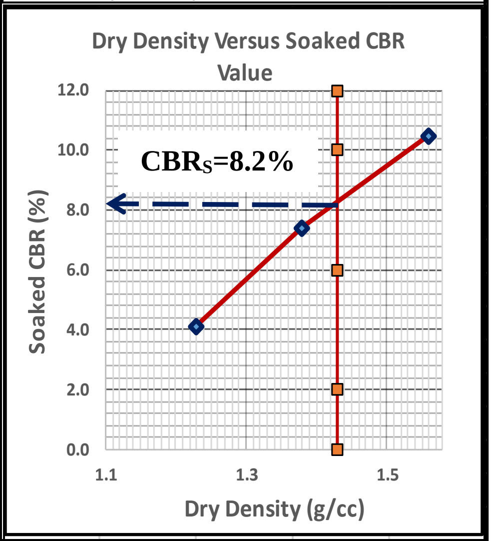


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.23	1.38	1.56
Specimen Load @ 2.54 mm	kN	0.543	0.98	1.386
Specimen Load @ 5.08 mm	kN	0.613	1.353	1.801
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.1	7.4	10.5
Soaked CBR value @ 5.08	%	3.1	6.8	9.0
Larger Soaked CBR Value	%	4.1	7.4	10.5
Data from Modified Compaction Proctor Test				
OMC	%	28.2		
MDD	g/cc	1.51		
Density required	%	95		
Target Density required	g/cc	1.43		
CBR Value at Target Density	%	**8.2**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test (AASHTO T 193-93)		
Site	Police Office	Test Pit	TP3 @ 1m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6525.4		6452.1		6474.2	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows per Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9898.2	10275.4	10214.6	10498.3	10490.6	10661.4
Weight of Wet soil	gram	3372.8	3750	3762.5	4046.2	4016.4	4187.2
Wet Density	g/cc	1.59	1.77	1.77	1.90	1.89	1.97

Moisture Content and Dry Density Determination

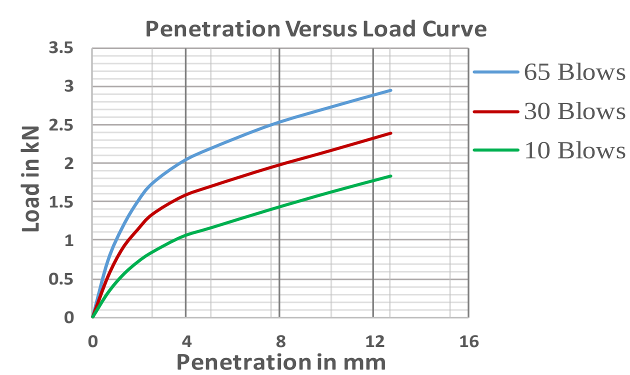
Container Code		MK	G3T3	MK1	G10	P2	10G	K-4	T1C1	O4-2	HC12	G3T3	N
Weight of cont. + wet soil	gram	90.5	88.8	100.3	91.7	100.3	90.1	99.2	100.2	102.1	94.6	100.6	93.8
Weight of cont. + dry soil	gram	75.3	73.9	77.0	71.0	83.6	75.2	78.0	77.8	85.0	79.2	79.1	73.5
Weight of water	gram	15.1	14.9	23.3	20.7	16.7	14.9	21.2	22.4	17.1	15.4	21.5	20.2
Weight of container	gram	17.6	17.6	17.6	17.2	17.5	17.7	17.9	17.7	17.7	18.2	17.6	16.8
Weight of Dry soil	gram	57.7	56.3	59.4	53.9	66.0	57.5	60.1	60.1	67.3	61.1	61.6	56.8
Moisture content	%	26.2	26.5	39.2	38.5	25.3	25.8	35.3	37.2	25.4	25.2	34.9	35.6
Avarege Moisture content	%	26.36		38.84		25.58		36.26		25.30		35.27	
Dry Density	g/cc	1.26		1.27		1.41		1.40		1.51		1.46	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.312	0.521	0.729
1.27	0.542	0.891	1.171
1.91	0.715	1.134	1.502
2.54	**0.845**	**1.334**	**1.74**
3.81	1.045	1.564	2.02
5.08	**1.165**	**1.702**	**2.201**
7.62	1.403	1.946	2.503
10.16	1.627	2.164	2.734
12.7	1.835	2.388	2.951

Plot of Penetration Versus Load Curve



Summary of CBR Value from the CBR Test Software

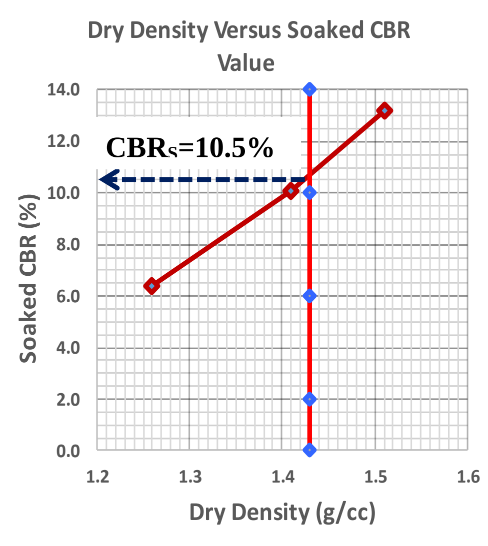
CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density (Bfre Soaking)	g/cc	1.26	1.41	1.51
Specimen Load @ 2.54 mm	kN	0.845	1.334	1.74
Specimen Load @ 5.08 mm	kN	1.165	1.702	2.201
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	6.4	10.1	13.2
Soaked CBR value @ 5.08	%	5.8	8.5	11.0
Larger Soaked CBR Value	%	6.4	10.1	13.2

Data from Modified Compaction Proctor Test

OMC	%	27.5
MDD	g/cc	1.51
Density required	%	95
Target Density required	g/cc	1.43
CBR Value at Target Density	%	**10.5**

Plot of Dry Density Versus Soaked CBR Value



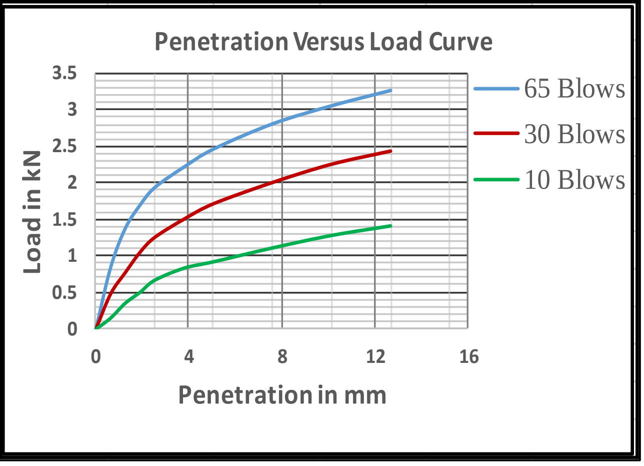
Test	California Bearing Ratio (CBR) Test, (AASHTO T-193)												
Site	Police Office								Test Pit		TP3 @ 2m		
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6524.5				6800.2				6504.6			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	9848.4		10323.8		10552.6		10790.1		10548.1		10795.1	
Weight of Wet soil	gram	3323.9		3799.3		3752.4		3989.9		4043.5		4270.6	
Wet Density	g/cc	1.56		1.79		1.77		1.88		1.9		2.01	
Moisture Content and Dry Density Determination													
Container Code		C	P3	H	G	14	O4	HC12	GS	O6	O5	F	G
Wt of cont. + wet soil	gram	99.1	97.2	55	148.3	73.8	78.7	112.6	91	66.3	57.6	67.1	69.1
Wt of cont. + dry soil	gram	84.9	82.1	41.6	118.7	62.2	66.4	87.4	71.8	56.3	49.6	51.6	52.8
Weight of water	gram	14.2	15.1	13.4	29.6	11.6	12.2	25.3	19.3	10	8	15.5	16.4
Weight of container	gram	32.8	25.8	5.7	37.9	17.4	17.6	18.1	18.4	17.1	17.8	6.3	5.6
Weight of Dry soil	gram	52.1	56.3	35.9	80.8	44.8	48.8	69.2	53.4	39.2	31.8	45.3	47.2
Moisture content	%	27.2	26.8	37.4	36.7	25.9	25	36.5	36.1	25.6	25.2	34.1	34.7
Av. Moisture content	%	27.01		37.01		25.48		36.29		25.39		34.4	
Dry Density	g/cc	1.23		1.31		1.41		1.38		1.52		1.5	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.153	0.483	0.848
1.27	0.356	0.772	1.381
1.91	0.505	1.05	1.701
2.54	**0.669**	**1.251**	**1.939**
3.81	0.834	1.501	2.222
5.08	**0.921**	**1.71**	**2.467**
7.62	1.11	1.999	2.811
10.16	1.28	2.247	3.058
12.7	1.41	2.426	3.267

Plot of Penetration Versus Load Curve

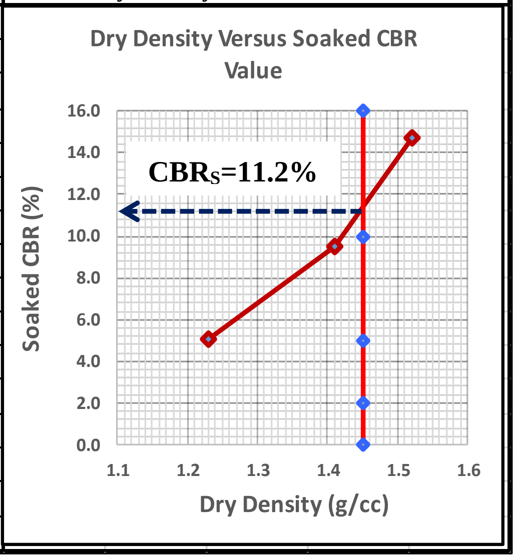


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.23	1.41	1.52
Specimen Load @ 2.54 mm	kN	0.669	1.251	1.939
Specimen Load @ 5.08 mm	kN	0.921	1.71	2.467
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	5.1	9.5	14.7
Soaked CBR value @ 5.08	%	4.6	8.6	12.3
Larger Soaked CBR Value	%	5.1	9.5	14.7
Data from Modified Compaction Proctor Test				
OMC	%	27.2		
MDD	g/cc	1.53		
Density required	%	95		
Target Density required	g/cc	1.45		
CBR Value at Target Density	%	**11.2**		

Plot of Dry Density Versus Soaked CBR Value



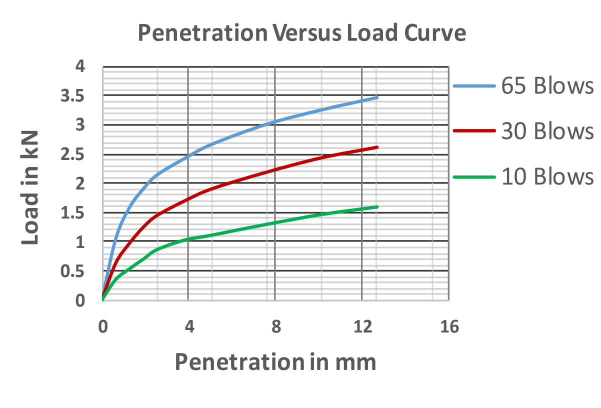
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	Police Office								Test Pit			TP3 @ 3m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6518.9				6501.7				6481.6			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of B/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weightt of Mold + wet s	gram	9839.1		10401.4		10251.8		10537.9		10588.5		10852.6	
Weight of Wet soil	gram	3320.2		3882.5		3750.1		4036.2		4106.9		4371	
Wet Density	g/cc	1.56		1.83		1.77		1.9		1.93		2.06	
Moisture Content and Dry Density Determination													
Container Code		C3	MK	T1	F	D	P15	G	DH	GS	SR	P15	MK
Weight of cont. + wet sc	gram	155.7	119.6	134.6	146.6	129.3	159.2	121.5	112.9	65.9	65.9	151.5	98.3
Weight of cont. + dry so	gram	129.3	98.8	108.5	117	109.1	133.6	94.5	87.7	57.6	57.8	121.3	77.4
Weight of water	gram	26.4	20.8	26.1	29.6	20.2	25.6	27	25.2	8.3	8.2	30.2	20.9
Weight of container	gram	26.7	17.6	37.7	36.4	29.6	33.5	17.9	17	25.2	25.3	33.5	17.6
Weight of Dry soil	gram	102.6	81.1	70.8	80.6	79.5	100.1	76.6	70.7	32.4	32.5	87.8	59.8
Moisture content	%	25.7	25.6	36.9	36.7	25.4	25.6	35.3	35.6	25.5	25.1	34.4	34.9
Av. Moisture content	%	25.68		36.8		25.49		35.42		25.3		34.67	
Dry Density	g/cc	1.24		1.34		1.41		1.4		1.54		1.53	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.353	0.633	1.048
1.27	0.536	0.972	1.581
1.91	0.705	1.25	1.901
2.54	**0.869**	**1.451**	**2.139**
3.81	1.034	1.701	2.422
5.08	**1.121**	**1.911**	**2.667**
7.62	1.31	2.199	3.011
10.16	1.48	2.447	3.258
12.7	1.61	2.626	3.467

Plot of Penetration Versus Load Curve

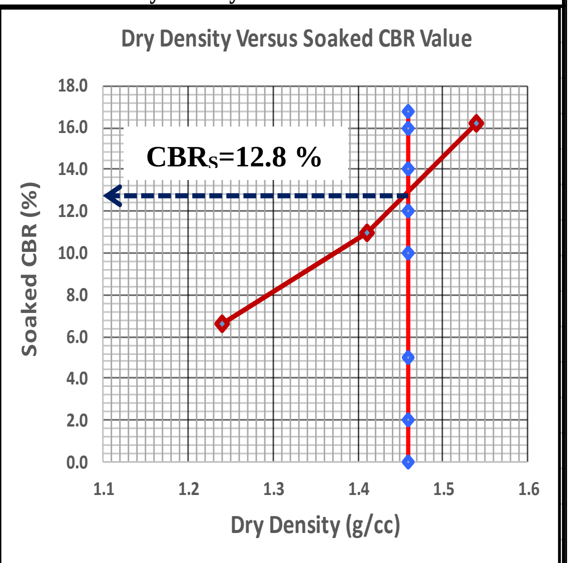


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.24	1.41	1.54
Specimen Load @ 2.54 mm	kN	0.869	1.451	2.139
Specimen Load @ 5.08 mm	kN	1.121	1.911	2.667
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	6.6	11.0	16.2
Soaked CBR value @ 5.08	%	5.6	9.6	13.3
Larger Soaked CBR Value	%	6.6	11.0	16.2
Data from Modified Compaction Proctor Test				
OMC	%	26.6		
MDD	g/cc	1.54		
Density required	%	95		
Target Density required	g/cc	1.46		
CBR Value at target Density	%	**12.8**		

Plot of Dry Density Versus Soaked CBR Value



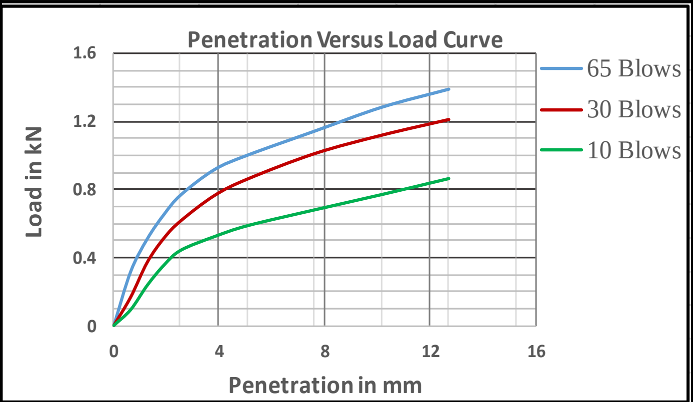
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	Administration Office								Test Pit			TP4 @ 1m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6445.9				6679.3				6471.6			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
No. of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold +wet so	gram	9988.4		10130.8		10478.1		10666		10618.4		10791.1	
Weight of Wet soil	gram	3542.5		3684.9		3798.8		3986.7		4146.8		4319.5	
Wet Density	g/cc	1.67		1.73		1.79		1.88		1.95		2.03	
Moisture Content and Dry Density Determination													
Container Code		T2	P15	F	G	D	SG	O1-1	O2-1	2	O3-1	P3	O6
Weight of cont. + wet so	gram	100.4	128.2	53.5	145.3	119	126.9	139.3	128.6	119.8	143.4	126.3	97.5
Weight of cont. + dry so	gram	79.4	104.3	39.6	113.7	96.8	102.5	110.6	100.9	98.9	119	101.7	75.6
Weight of water	gram	21	23.9	13.9	31.6	22.1	24.4	28.8	27.7	20.9	24.4	24.6	21.9
Weight of container	gram	17.6	33.6	5.7	37.9	26.6	25.4	40.2	28.3	34.7	36.7	36	17.4
Weight of Dry soil	gram	61.8	70.7	33.9	75.8	70.2	77.1	70.4	72.6	64.3	82.3	65.7	58.2
Moisture content	%	34	33.8	41	41.7	31.5	31.7	40.9	38.2	32.5	29.6	37.5	37.6
Av. Moisture content	%	33.89		41.38		31.59		39.54		31.06		37.56	
Dry Density	g/cc	1.25		1.23		1.36		1.35		1.49		1.48	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.093	0.167	0.317
1.27	0.237	0.372	0.509
1.91	0.357	0.515	0.654
2.54	**0.443**	**0.615**	**0.767**
3.81	0.523	0.763	0.915
5.08	**0.588**	**0.861**	**1.001**
7.62	0.681	1.01	1.142
10.16	0.771	1.118	1.282
12.7	0.865	1.21	1.388

Plot of Penetration Versus Load Curve

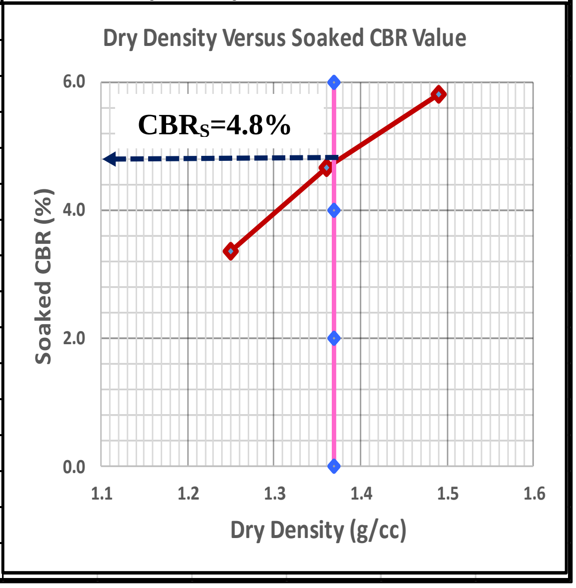


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.25	1.36	1.49
Specimen Load @ 2.54 mm	kN	0.443	0.615	0.767
Specimen Load @ 5.08 mm	kN	0.588	0.861	1.001
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	3.4	4.7	5.8
Soaked CBR value @ 5.08	%	2.9	4.3	5.0
Larger Soaked CBR Value	%	3.4	4.7	5.8
Data from Modified Compaction Proctor Test				
OMC	%	35		
MDD	g/cc	1.44		
Density required	%	95		
Target Density required	g/cc	1.37		
CBR Value at target Density	%	**4.8**		

Plot of Dry Density Versus Soaked CBR Value



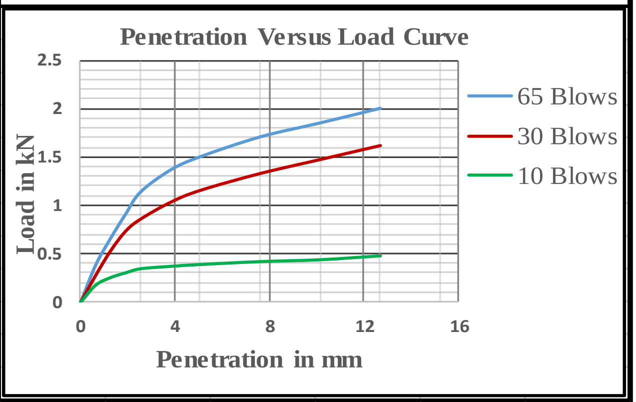
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)											
Site	Administration Office								Test Pit		TP4 @ 2m	
Wet Density Determination												
	Units											
Mold No.		1				2				3		
Mass of Mold	gram	6590.3				6555.6				6515.5		
Volume of Mold	cc	2124				2124				2124		
No.of Layer		5				5				5		
No. of Blows/Layer		10				30				65		
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking
Weight of Mold + wet soil	gram	10180.8		10495.3		10481.2		10694.6		10741.2		10864.7
Weight of Wet soil	gram	3590.5		3905		3925.6		4139		4225.7		4349.2
Wet Density	g/cc	1.69		1.84		1.85		1.95		1.99		2.05
Moisture Content and Dry Density Determination												
Container Code		F	T1	T1C1	O6-1	G3T3	K-4	F	G	TC1	G19	O4-	MK
Weight of cont. + wet soil	gram	124.3	128.2	101.6	108.4	158.1	106.2	163.6	116.3	85.4	118.1	116.1	112.8
Weight of cont. + dry soil	gram	103.2	106.3	75.2	79.8	129	85.4	127.9	88.9	68.9	99	89.7	87.1
Weight of water	gram	21.1	21.8	26.4	28.6	29.1	20.7	35.8	27.5	16.5	19.1	26.4	25.7
Weight of container	gram	36.4	37.7	17.6	17.9	37.9	17.9	36.4	17.7	17.7	37.9	17.6	17.6
Weight of Dry soil	gram	66.8	68.7	57.6	61.9	91.1	67.5	91.4	71.1	51.1	61.1	72.1	69.5
Moisture content	%	31.5	31.8	45.9	46.2	32	30.7	39.1	38.6	32.3	31.3	36.7	37
Av.M oisture content	%	31.65		46.03		31.34		38.85		31.83		36.84	
Dry Density	g/cc	1.28		1.26		1.41		1.4		1.51		1.5	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.174	0.278	0.386
1.27	0.25	0.528	0.66
1.91	0.298	0.731	0.911
2.54	**0.339**	**0.854**	**1.138**
3.81	0.363	1.027	1.365
5.08	**0.382**	**1.15**	**1.503**
7.62	0.411	1.323	1.707
10.16	0.43	1.466	1.851
12.7	0.469	1.609	2.001

Plot of Penetration Versus Load Curve

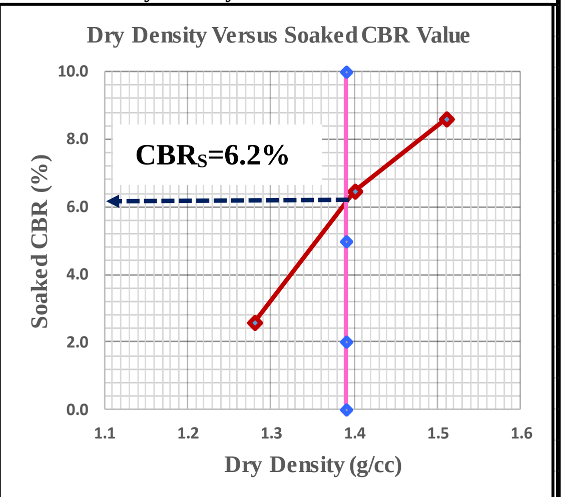


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.28	1.4	1.51
Specimen Load @ 2.54 mm	kN	0.339	0.854	1.138
Specimen Load @ 5.08 mm	kN	0.382	1.15	1.503
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.6	6.5	8.6
Soaked CBR value @ 5.08	%	1.9	5.8	7.5
Reported Soaked CBR Value	%	2.6	6.5	8.6
Data from Modified Compaction Proctor Test				
OMC	%	33.1		
MDD	g/cc	1.46		
Density required	%	95		
Target Density required	g/cc	1.39		
CBR Value at target Density	%	**6.2**		

Plot of Dry Density Versus Soaked CBR Value



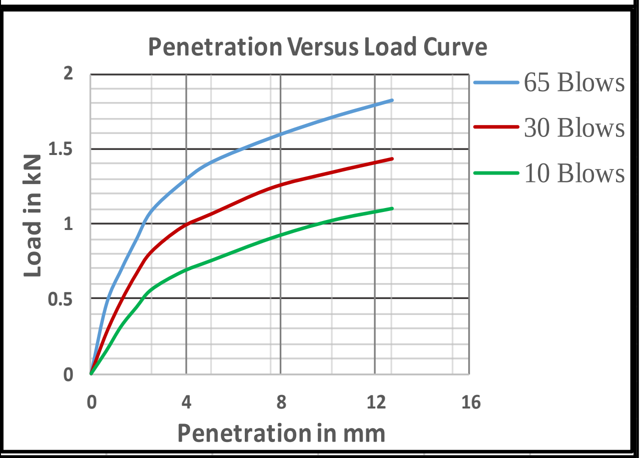
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	**Administration Office**								Test Pit			TP4 @ 3m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6608.4				6647.4				6651.8			
Volume of Mold	cc	2124				2124				2124			
No. of Layer		5				5				5			
No. of Blows per Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	9983.3		10477.2		10372.2		10787.6		10670.9		10894.9	
Weight of Wet soil	gram	3374.9		3868.8		3724.8		4140.2		4019.1		4243.1	
Wet Density	g/cc	1.59		1.82		1.75		1.95		1.89		2	
Moisture Content and Dry Density Determination													
Container Code		B	DH	G3T3	K-4	G-1	P6	G19	T1C1	G	UC	A-1C	P66
Weight of cont. + wet soil	gram	95.3	94.3	166.1	109.2	86.7	88.4	166.2	101.9	63.2	74.4	174.5	166.6
Weight of cont. + dry soil	gram	78	76.9	123.5	78.9	71.2	72.4	126.9	76.2	52.6	61.4	139.5	131.2
Weight of water	gram	17.3	17.4	42.6	30.3	15.6	16	39.3	25.7	10.6	13	35	35.4
Weight of container	gram	18.2	17	37.9	17.9	17.8	17.1	37.9	17.7	17.9	16.7	49.7	37.5
Weight of Dry soil	gram	59.8	59.8	85.6	61	53.4	55.3	89	58.4	34.6	44.7	89.8	93.7
Moisture content	%	29	29.1	49.7	49.6	29.2	28.9	44.2	44	30.6	29	38.9	37.8
Av. Moisture content	%	29.02		49.66		29.04		44.11		29.8		38.34	
Dry Density	g/cc	1.23		1.22		1.36		1.35		1.46		1.44	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.152	0.269	0.46
1.27	0.317	0.482	0.693
1.91	0.443	0.664	0.895
2.54	**0.561**	**0.81**	**1.083**
3.81	0.678	0.971	1.27
5.08	**0.756**	**1.062**	**1.41**
7.62	0.906	1.235	1.574
10.16	1.023	1.338	1.709
12.7	1.103	1.428	1.823

Plot of Penetration Versus Load Curve

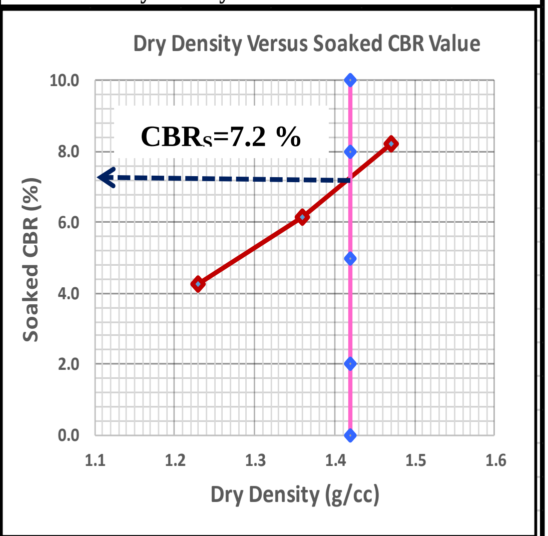


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.23	1.36	1.47
Specimen Load @ 2.54 mm	kN	0.561	0.81	1.083
Specimen Load @ 5.08 mm	kN	0.756	1.052	1.41
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.3	6.1	8.2
Soaked CBR value @ 5.08	%	3.8	5.3	7.1
Larger Soaked CBR Value	%	4.3	6.1	8.2
Data from Modified Compaction Proctor Test				
OMC	%	31.2		
MDD	g/cc	1.49		
Density required	%	95		
Target Density required	g/cc	1.42		
CBR Value at target Density	%	**7.2**		

Plot of Dry Density Versus Soaked CBR Value



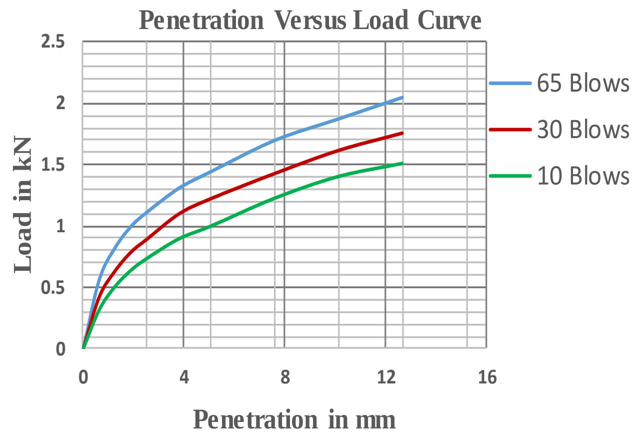
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	Seka town municipality Office									Test Pit		TP5 @ 1m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6534.9				6639.7				6462.9			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	10064.1		10303.7		10333.5		10526.6		10404.3		10608.9	
Weight of Wet soil	gram	3529.2		3768.8		3693.8		3886.9		3941.4		4146	
Wet Density	g/cc	1.66		1.77		1.74		1.83		1.86		1.95	
Moisture Content and Dry Density Determination													
Container Code		G6	SR	P10	O1	M	S-2	O6-1	O62	G-9	N	13	SB
Weight of cont. + wet soil	gram	81.2	87.3	106.4	95.6	126.3	90.2	93.2	97.9	83.7	86.9	94.2	117.7
Weight of cont. + dry soil	gram	68.4	73.0	82.1	74.3	106.8	73.4	73.4	77.0	69.0	71.0	74.9	92.2
Weight of water	gram	12.9	14.3	24.3	21.4	19.5	16.8	19.8	20.9	14.7	15.9	19.3	25.5
Weight of container	gram	25.2	25.3	17.5	17.5	40.2	17.9	17.5	17.4	17.8	16.8	18.2	18.4
Weight of Dry soil	gram	43.2	47.7	64.6	56.7	66.6	55.5	55.9	59.6	51.2	54.2	56.6	73.8
Moisture content	%	29.8	29.9	37.6	37.7	29.2	30.3	35.5	35.0	28.8	29.2	34.1	34.5
Av. Moisture content	%	29.86		37.62		29.74		35.23		29.01		34.31	
Dry Density	g/cc	1.28		1.29		1.34		1.35		1.44		1.45	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.32	0.422	0.564
1.27	0.51	0.632	0.824
1.91	0.644	0.786	0.999
2.54	**0.74**	**0.89**	**1.114**
3.81	0.9	1.094	1.309
5.08	**1.004**	**1.218**	**1.444**
7.62	1.232	1.422	1.699
10.16	1.41	1.609	1.874
12.7	1.517	1.75	2.049

Plot of Penetration Versus Load Curve

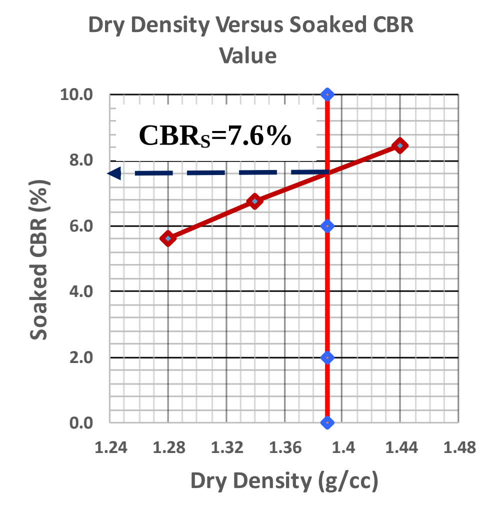


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.28	1.34	1.44
Specimen Load @ 2.54 mm	kN	0.74	0.89	1.114
Specimen Load @ 5.08 mm	kN	1.004	1.218	1.444
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	5.6	6.7	8.4
Soaked CBR value @ 5.08	%	5.0	6.1	7.2
Larger Soaked CBR Value	%	5.6	6.7	8.4
Data from Modified Compaction Proctor Test				
OMC	%	32		
MDD	g/cc	1.46		
Density required	%	95		
Target Density required	g/cc	1.39		
CBR Value at Target Density	%	**7.6**		

Plots of Dry Density Versus Soaked CBR Value



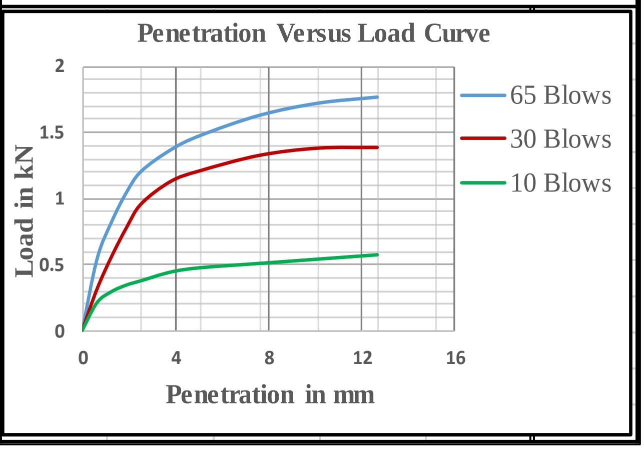
Test	California Bearing Ratio (CBR) Test,(AASHTO T 193-93)												
Site	Seka Town Municipality Office									Test Pit		TP5 @ 2m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6430.6				6492.1				6436			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	10029.8		10460.7		10349.3		10610.1		10402.5		10648.8	
Weight of Wet soil	gram	3599.2		4030.1		3857.2		4118		3966.5		4212.8	
Wet Density	g/cc	1.69		1.90		1.82		1.94		1.87		1.98	
Moisture Content and Dry Density Determination													
Container Code		S-3	P65	P2	O61	T1	P6	O6-3	14	O2-3	14	AT	G-2
Weight of cont. + wet soil	gram	104.0	156.8	101.7	92.5	152.5	144.0	93.5	103.6	98.4	95.0	95.8	105.7
Weight of cont. + dry soil	gram	84.5	130.2	77.2	70.8	125.5	118.9	72.5	79.9	80.1	77.9	74.9	82.7
Weight of water	gram	19.5	26.6	24.5	21.8	27.0	25.1	21.1	23.7	18.3	17.2	21.0	23.0
Weight of container	gram	17.6	37.8	17.7	17.9	31.6	31.7	17.1	17.4	17.7	17.5	17.6	18.0
Weight of Dry soil	gram	66.9	92.4	59.5	52.8	93.9	87.2	55.3	62.5	62.4	60.3	57.3	64.8
Moisture content	%	29.1	28.8	41.2	41.2	28.8	28.7	38.1	38.0	29.3	28.5	36.6	35.5
Av.Moisture content	%	28.96		41.19		28.77		38.03		28.88		36.05	
Dry Density	g/cc	1.31		1.34		1.41		1.40		1.45		1.46	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.212	0.314	0.543
1.27	0.296	0.561	0.826
1.91	0.346	0.779	1.049
2.54	**0.379**	**0.958**	**1.208**
3.81	0.445	1.128	1.371
5.08	**0.478**	**1.209**	**1.48**
7.62	0.511	1.325	1.633
10.16	0.544	1.38	1.726
12.7	0.577	1.385	1.772

Plots of Penetration Versus Load Curve

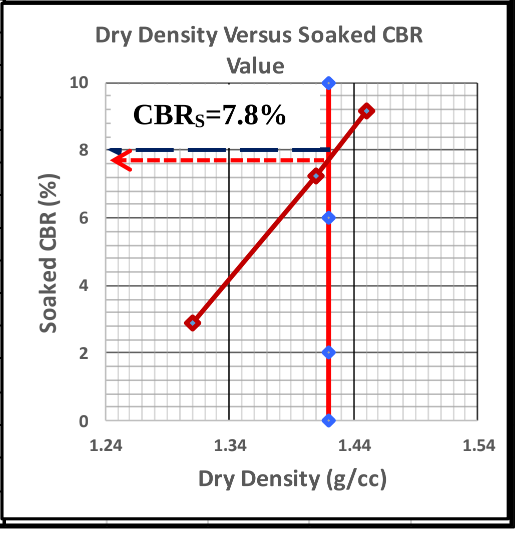


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.31	1.41	1.45
Specimen Load @ 2.54 mm	kN	0.379	0.958	1.208
Specimen Load @ 5.08 mm	kN	0.478	1.209	1.478
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.9	7.3	9.2
Soaked CBR value @ 5.08	%	2.4	6.0	7.4
Larger Soaked CBR Value	%	2.9	7.3	9.2
Data from Modified Compaction Proctor Test				
OMC	%	29.7		
MDD	g/cc	1.49		
Density required	%	95		
Target Density required	g/cc	1.42		
CBR value at Target Density	%	**7.8**		

Plots of Dry Density Versus Soaked CBR Value



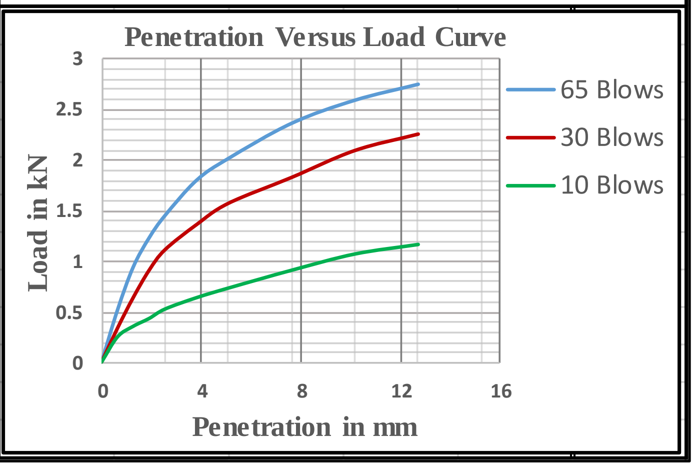
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)											
Site	Seka Town Municipality Office								Test Pit		TP5 @ 3m	
Wet Density Determination												
	Units											
Mold Number		1				2			3			
Mass of Mold	gram	6638.3				6608.6			6473.1			
Volume of Mold	cc	2124				2124			2124			
Number of Layer		5				5			5			
Number of Blows/Layer		10				30			65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking	Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	10185.9		10592.6		10428.6		10696.3	10552.4		10828.5	
Weight of Wet soil	gram	3547.6		3954.3		3820		4087.7	4079.3		4355.4	
Wet Density	g/cc	1.67		1.86		1.80		1.92	1.92		2.05	
Moisture Content and Dry Density Determination												
Container Code		ZE	A16	T1	G3T3	C3	P2	D	E	P10	NB	12	N
Weight of cont. + wet soil	gram	142.9	145.8	154.2	140.8	110.4	123.0	138.9	148.7	96.1	95.2	109.4	113.3
Weight of cont. + dry soil	gram	119.7	122.0	119.5	110.2	92.8	100.5	108.2	113.5	79.0	78.2	87.1	87.2
Weight of water	gram	23.2	23.9	34.7	30.6	17.6	22.5	30.6	35.3	17.1	17.0	22.3	26.0
Weight of container	gram	33.1	32.9	37.7	37.9	26.7	17.7	27.2	18.3	17.5	17.6	28.1	18.2
Weight of Dry soil	gram	86.6	89.1	81.9	72.3	66.1	82.8	81.0	95.2	61.4	60.6	59.0	69.0
Moisture content	%	26.8	26.8	42.3	42.3	26.6	27.1	37.8	37.0	27.9	28.0	37.8	37.7
Av. Moisture content	%	26.77		42.34		26.85		37.40		27.91		37.75	
Dry Density	g/cc	1.32		1.31		1.42		1.40		1.50		1.49	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.251	0.338	0.517
1.27	0.356	0.642	0.942
1.91	0.434	0.914	1.231
2.54	**0.527**	**1.116**	**1.45**
3.81	0.641	1.367	1.8
5.08	**0.736**	**1.578**	**2.015**
7.62	0.914	1.836	2.364
10.16	1.076	2.104	2.593
12.7	1.171	2.267	2.751

Plots of Penetration Versus Load Curve

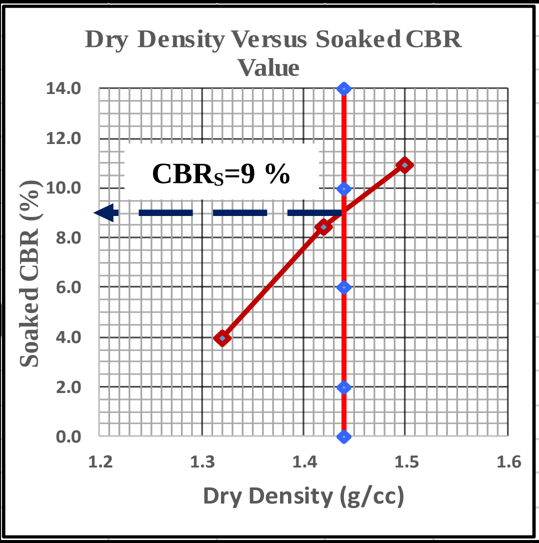


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		**10**	**30**	**65**
Dry Density	g/cc	1.32	1.42	1.5
Specimen Load @ 2.54 mm	kN	0.527	1.116	1.45
Specimen Load @ 5.08 mm	kN	0.736	1.578	2.015
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.0	8.5	11.0
Soaked CBR value @ 5.08	%	3.7	7.9	10.1
Larger Soaked CBR Value	%	4.0	8.5	11.0
Data from Modified Compaction Proctor Test				
OMC	%	27.6		
MDD	g/cc	1.52		
Density required	%	95		
Target Density required	g/cc	1.44		
CBR Value at Target Density	%	**9.0**		

Plots of Dry Density Versus Soaked CBR Value



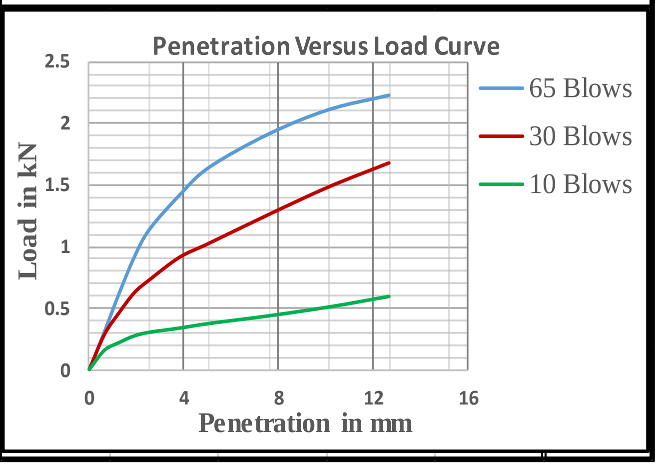
Test	California Bearing Ratio (CBR) Test, (AASHTO T1 93-93)												
Site	Seka High School								Test Pit			TP6 @ 1m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6603				6618				6496.5			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	10145.4		10388.9		10342.5		10537.8		10547.9		10671.8	
Weight of Wet soil	gram	3542.4		3785.9		3724.5		3919.8		4051.4		4175.3	
Wet Density	g/cc	1.67		1.78		1.75		1.85		1.91		1.97	
Moisture Content and Dry Density Determination													
Container Code		O4-2	O4-1	10G	B3	MK	G	O1-3	G7	O6-1	P1	K-4	T1C1
Weight of cont. + wet soil	gram	89.3	84.7	90.8	82.5	74.4	91.5	114.0	99.9	57.9	49.1	115.3	103.8
Weight of cont. + dry soil	gram	72.4	69.1	69.1	63.3	60.9	73.9	87.2	76.6	48.2	41.8	89.5	81.0
Weight of water	gram	16.9	15.7	21.7	19.2	13.4	17.6	26.8	23.2	9.6	7.3	25.8	22.8
Weight of container	gram	17.7	17.6	17.7	17.4	17.6	17.7	17.5	17.4	17.5	17.9	17.9	17.7
Weight of Dry soil	gram	54.7	51.5	51.4	45.9	43.3	56.2	69.7	59.3	30.7	23.9	71.5	63.3
Moisture content	%	30.9	30.5	42.2	41.8	31.0	31.3	38.5	39.2	31.4	30.6	36.1	36.0
Av. Moisture content	%	30.70		42.01		31.15		38.84		31.00		36.03	
Dry Density	g/cc	1.28		1.26		1.34		1.33		1.46		1.45	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.156	0.283	0.305
1.27	0.22	0.463	0.62
1.91	0.274	0.624	0.913
2.54	**0.303**	**0.727**	**1.134**
3.81	0.337	0.91	1.412
5.08	**0.375**	**1.026**	**1.641**
7.62	0.438	1.261	1.913
10.16	0.51	1.485	2.11
12.7	0.596	1.679	2.226

Plot of Penetration Versus Load Curve

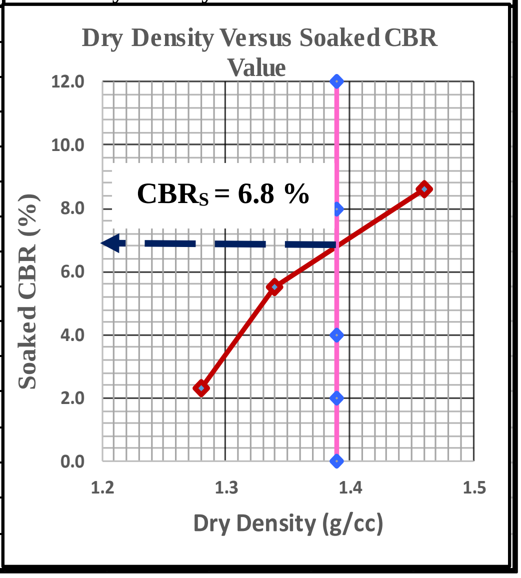


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.28	1.34	1.46
Specimen Load @ 2.54 mm	kN	0.303	0.727	1.134
Specimen Load @ 5.08 mm	kN	0.375	1.026	1.641
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.3	5.5	8.6
Soaked CBR value @ 5.08	%	1.9	5.1	8.2
Larger Soaked CBR Value	%	2.3	5.5	8.6
Data from Modified Compaction Proctor Test				
OMC	%	33.5		
MDD	g/cc	1.46		
Density required	%	95		
Target Density required	g/cc	1.39		
CBR value at Target Density	%	**6.8**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Seka High School	Test Pit	TP6 @ 2m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6536.4		6686		6321.2	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9999.8	10329.9	10371.7	10622.1	10432.5	10642.3
Weight of Wet soil	gram	3463.4	3793.5	3685.7	3936.1	4111.3	4321.1
Wet Density	g/cc	1.63	1.79	1.74	1.85	1.94	2.03

Moisture Content and Dry Density Determination

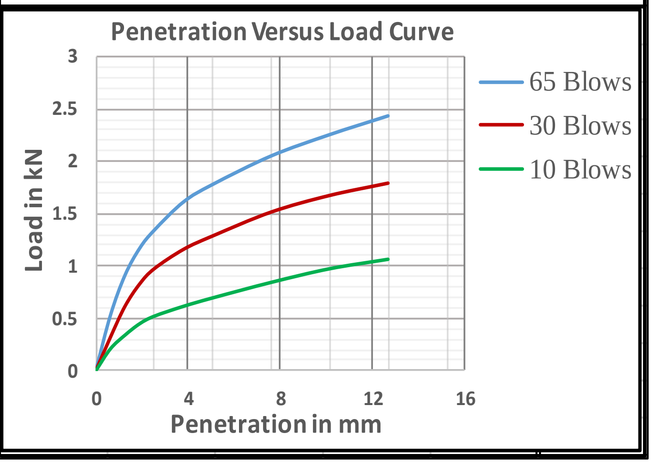
Container Code		RG	P66	O5-2	O2-3	P3	A-13	II	G19	ZE	D	113	P66
Weight of cont. + wet soil	gram	152.2	161.1	95.8	105.0	109.0	105.4	105.4	108.1	122.1	109.0	142.3	144.5
Weight of cont. + dry soil	gram	125.8	135.3	74.9	81.4	94.1	90.9	82.6	84.5	103.1	92.1	115.3	117.2
Weight of water	gram	26.4	25.8	20.9	23.6	14.9	14.6	22.8	23.5	18.9	16.9	27.0	27.4
Weight of container	gram	25.2	37.4	17.9	17.7	36.0	36.6	18.0	17.8	33.1	29.6	37.9	37.4
Weight of Dry soil	gram	100.6	97.9	57.0	63.8	58.2	54.3	64.6	66.7	70.0	62.5	77.4	79.8
Moisture content	%	26.2	26.3	36.6	37.0	25.5	26.8	35.3	35.2	27.1	27.0	34.9	34.3
Av.Moisture content	%	26.26		36.81		26.17		35.26		27.01		34.58	
Dry Density	g/cc	1.29		1.31		1.38		1.37		1.52		1.51	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.212	0.321	0.534
1.27	0.343	0.614	0.916
1.91	0.453	0.827	1.175
2.54	**0.525**	**0.971**	**1.347**
3.81	0.62	1.155	1.618
5.08	**0.701**	**1.283**	**1.786**
7.62	0.85	1.51	2.059
10.16	0.981	1.668	2.263
12.7	1.072	1.785	2.443

Plot of Penetration Versus Load Curve



Summary of CBR Value from the CBR Test Software

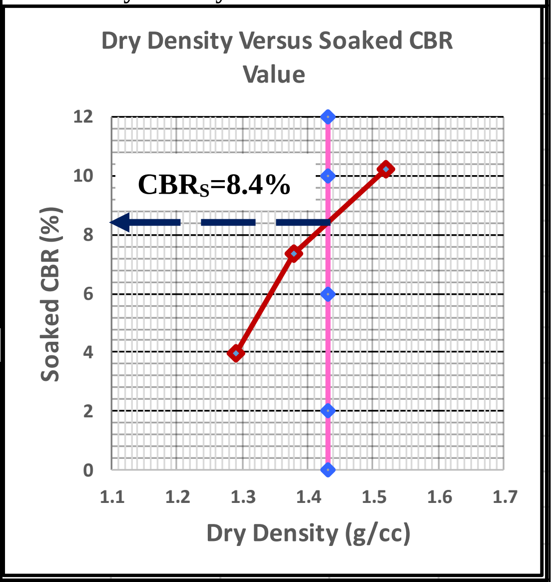
CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.29	1.38	1.52
Specimen Load @ 2.54 mm	kN	0.525	0.971	1.347
Specimen Load @ 5.08 mm	kN	0.701	1.283	1.786
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.0	7.4	10.2
Soaked CBR value @ 5.08	%	3.5	6.4	8.9
Larger Soaked CBR Value	%	4.0	7.4	10.2

Data from Modified Compaction Proctor Test

OMC	%	27.6
MDD	g/cc	1.5
Density required	%	95
Target Density required	g/cc	1.43
CBR value at Target Density	%	**8.4**

Plot of Dry Density Versus Soaked CBR Value



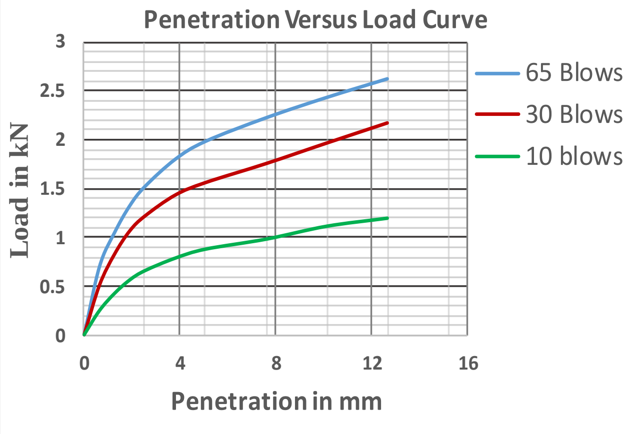
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	Seka Town Agricultural and Natural Resource Office									Test Pit		TP6 @ 3m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6803				6805.4				6531.6			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/ Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	10100.1		10516.7		10547.2		10782.1		10610		10801.6	
Weight of Wet soil	gram	3297.1		3713.7		3741.8		3976.7		4078.4		4270	
Wet Density	g/cc	1.55		1.75		1.76		1.87		1.92		2.01	
Moisture Content and Dry Density Determination													
Container Code		P66	A-1C	P2	HC51	MK	P15	AT	II	DH	G	HC12	10G
Weight of cont. + wet soil	gram	116.7	127.8	121.1	121.0	83.4	115.8	114.2	116.7	80.2	94.0	111.6	112.7
Weight of cont. + dry soil	gram	100.9	112.3	93.9	93.7	70.5	99.2	89.1	91.1	67.3	78.6	88.8	89.0
Weight of water	gram	15.8	15.5	27.3	27.3	12.9	16.5	25.2	25.6	12.8	15.3	22.8	23.8
Weight of container	gram	37.5	49.7	17.5	17.7	17.6	33.5	17.6	18.0	17.0	17.9	18.1	17.7
Weight of Dry soil	gram	63.4	62.6	76.3	76.1	52.9	65.7	71.5	73.1	50.3	60.7	70.7	71.2
Moisture content	%	25.0	24.8	35.7	35.8	24.4	25.2	35.2	35.0	25.5	25.3	32.2	33.4
Av. Moisture content	%	24.88		35.79		24.80		35.12		25.37		32.80	
Dry Density	g/cc	1.24		1.29		1.41		1.39		1.53		1.51	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.246	0.507	0.698
1.27	0.421	0.824	1.047
1.91	0.559	1.063	1.324
2.54	**0.653**	**1.214**	**1.52**
3.81	0.781	1.429	1.8
5.08	**0.873**	**1.557**	**1.985**
7.62	0.975	1.752	2.227
10.16	1.107	1.962	2.436
12.7	1.189	2.168	2.627

Plot of Penetration Versus Load Curve

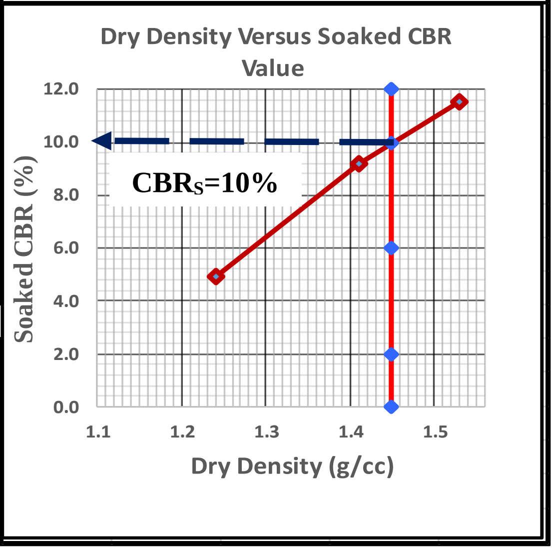


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.24	1.41	1.53
Specimen Load @ 2.54 mm	kN	0.653	1.214	1.52
Specimen Load @ 5.08 mm	kN	0.873	1.557	1.985
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.9	9.2	11.5
Soaked CBR value @ 5.08	%	4.4	7.8	9.9
Larger Soaked CBR Value	%	4.9	9.2	11.5
Data from Modified Compaction Proctor Test				
OMC	%	26.4		
MDD	g/cc	1.53		
Density required	%	95		
Target Density required	g/cc	1.45		
CBR value at Target Density	%	**10.0**		

Plot of Dry Density Versus Soaked CBR Value



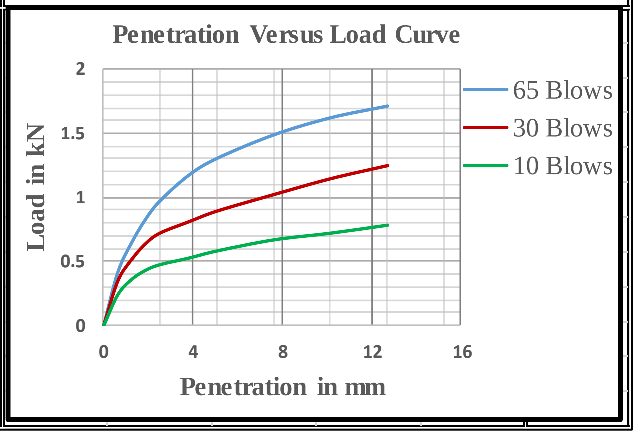
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	New Generation KG School								Test Pit		TP7 @ 1m		
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6658.9				6601.7				6551.6			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Wt of Mold + wet soil	gram	10149.1		10491.4		10322.8		10557.9		10528.5		10702.6	
Weight of Wet soil	gram	3490.2		3832.5		3721.1		3956.2		3976.9		4151	
Wet Density	g/cc	1.64		1.80		1.75		1.86		1.87		1.95	
Moisture Content and Dry Density Determination													
Container Code		C3	MK	T1	F	D	P15	G	DH	GS-6	SR	P15	MK
Wt of cont. + wet soil	gram	154.7	119.6	133.9	145.8	128.8	158.6	121.5	112.9	65.3	64.9	151.5	98.3
Wt of cont. + dry soil	gram	123.7	94.8	103.5	111.0	105.1	128.6	90.5	84.7	55.6	55.6	119.3	76.4
Weight of water	gram	31.0	24.8	30.4	34.8	23.7	30.0	31.0	28.2	9.6	9.3	32.2	21.9
Weight of container	gram	26.7	17.6	37.7	36.4	29.6	33.5	17.9	17.0	25.2	25.3	33.5	17.6
Weight of Dry soil	gram	97.0	77.1	65.8	74.6	75.5	95.1	72.6	67.7	30.4	30.3	85.8	58.8
Moisture content	%	32.0	32.1	46.2	46.6	31.4	31.6	42.7	41.6	31.7	30.8	37.5	37.2
Av. Moisture content	%	32.07		46.43		31.47		42.15		31.22		37.39	
Dry Density	g/cc	1.24		1.23		1.33		1.31		1.43		1.42	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.244	0.353	0.42
1.27	0.364	0.523	0.654
1.91	0.436	0.649	0.84
2.54	**0.478**	**0.728**	**0.978**
3.81	0.528	0.815	1.175
5.08	**0.584**	**0.899**	**1.307**
7.62	0.67	1.028	1.49
10.16	0.722	1.152	1.623
12.7	0.784	1.254	1.714

Plot of Penetration Versus Load Curve

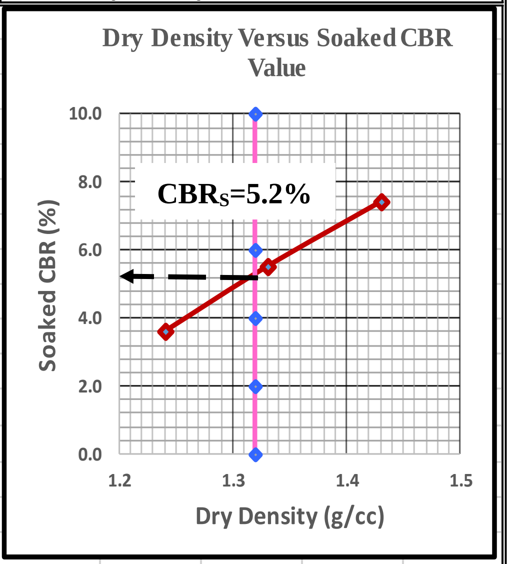


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.24	1.33	1.43
Specimen Load @ 2.54 mm	kN	0.478	0.728	0.978
Specimen Load @ 5.08 mm	kN	0.584	0.899	1.307
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	3.6	5.5	7.4
Soaked CBR value @ 5.08	%	2.9	4.5	6.5
Larger Soaked CBR Value	%	3.6	5.5	7.4
Data from Modified Compaction Proctor Test				
OMC	%	34.2		
MDD	g/cc	1.39		
Density required	%	95		
Target Density required	g/cc	1.32		
CBR Value at target Density	%	**5.2**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	New Generation KG School	Test Pit	TP7 @ 2m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6624.5		6880.2		6634.6	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9998.4	10353.8	10592.6	10798.1	10698.1	10847.1
Weight of Wet soil	gram	3373.9	3729.3	3712.4	3917.9	4073.6	4222.6
Wet Density	g/cc	1.59	1.76	1.75	1.84	1.92	1.99

Moisture Content and Dry Density Determination

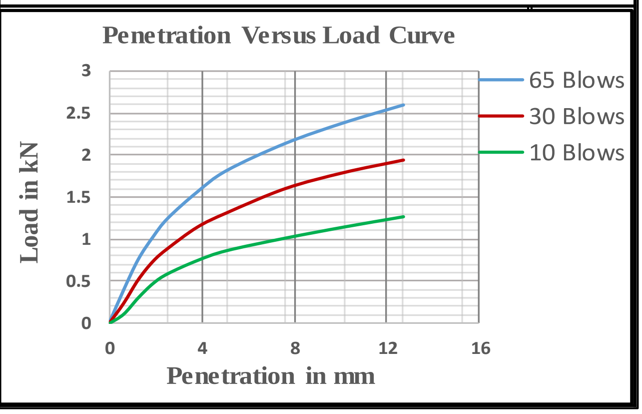
Container Code		C	P3	H	G	14	O4-3	HC12	GS=3	O6-3	O5-2	F	G
Weight of cont. + wet soil	gram	98.2	96.1	55.0	148.3	73.6	77.2	112.6	91.0	64.4	56.1	68.7	69.5
Weight of cont. + dry soil	gram	84.2	81.1	39.6	113.7	61.6	64.4	85.4	70.0	54.2	47.9	51.9	52.0
Weight of water	gram	14.0	15.0	15.4	34.6	12.0	12.7	27.3	21.1	10.2	8.2	16.8	17.6
Weight of container	gram	32.8	25.8	5.7	37.9	17.4	17.6	18.1	18.4	17.1	17.8	6.3	5.6
Weight of Dry soil	gram	51.4	55.3	33.9	75.8	44.2	46.8	67.2	51.6	37.1	30.1	45.6	46.4
Moisture content	%	27.3	27.1	45.5	45.7	27.2	27.2	40.5	40.9	27.4	27.2	36.8	37.8
Av. Moisture content	%	27.19		45.57		27.18		40.70		27.33		37.33	
Dry Density	g/cc	1.25		1.21		1.37		1.31		1.51		1.45	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.113	0.243	0.404
1.27	0.306	0.522	0.767
1.91	0.475	0.74	1.036
2.54	**0.589**	**0.891**	**1.255**
3.81	0.744	1.142	1.568
5.08	**0.861**	**1.312**	**1.823**
7.62	1.009	1.6	2.147
10.16	1.14	1.79	2.394
12.7	1.26	1.936	2.603

Plot of Penetration Versus Load Curve



Summary of CBR Value from the CBR Test Software

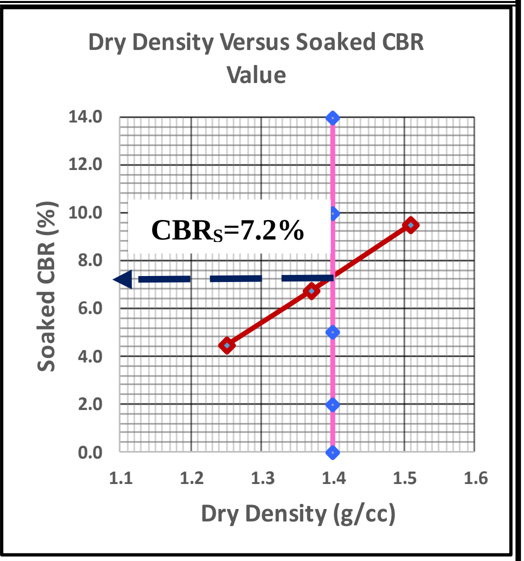
CBR Test Summary Value

	Units			
Number of blows		**10**	**30**	**65**
Dry Density	g/cc	1.25	1.37	1.51
Specimen Load @ 2.54 mm	kN	0.589	0.891	1.255
Specimen Load @ 5.08 mm	kN	0.861	1.312	1.823
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.5	6.8	9.5
Soaked CBR value @ 5.08	%	4.3	6.6	9.1
Larger Soaked CBR Value	%	4.5	6.8	9.5

Data from Modified Compaction Proctor Test

OMC	%	29.8
MDD	g/cc	1.47
Density required	%	95
Target Density required	g/cc	1.40
CBR value at Target Density	%	**7.2**

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	New Generation KG School	Test Pit	TP7 @ 3m

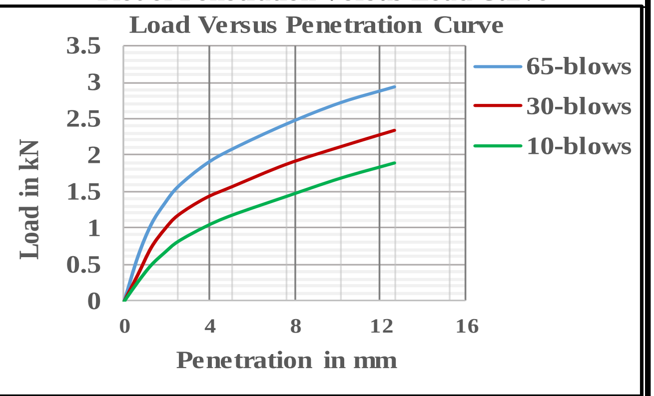
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6525.4				6462.1				6464.2			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	9929.2		10315.4		10140.6		10408.3		10501.6		10701.4	
Weight of Wet soil	gram	3403.8		3790		3678.5		3946.2		4037.4		4237.2	
Wet Density	g/cc	1.60		1.78		1.73		1.86		1.90		1.99	
Moisture Content and Dry Density Determination													
Container Code		MK	G3T3	MK1	G10	P2	10G	K-4	T1C1	O4-2	HC12	G3T3	N
Weight of cont. + wet soil	gram	93.3	91.4	101.3	93.3	99.5	89.8	98.0	97.5	102.6	95.2	101.6	95.2
Weight of cont. + dry soil	gram	77.3	75.7	78.0	72.0	82.4	75.1	76.7	76.2	84.7	78.9	80.3	75.2
Weight of water	gram	16.0	15.7	23.3	21.4	17.2	14.7	21.3	21.3	18.0	16.3	21.3	20.0
Weight of container	gram	17.6	17.6	17.6	17.2	17.5	17.7	17.9	17.7	17.7	18.2	17.6	16.8
Weight of Dry soil	gram	59.6	58.1	60.3	54.8	64.8	57.4	58.8	58.5	67.0	60.7	62.8	58.5
Moisture content	%	26.8	27.1	38.7	39.0	26.5	25.6	36.2	36.5	26.8	26.9	33.9	34.2
Av.Moisture content	%	26.91		38.85		26.05		36.33		26.84		34.05	
Dry Density	g/cc	1.26		1.29		1.37		1.36		1.50		1.49	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.262	0.361	0.608
1.27	0.492	0.731	1.05
1.91	0.665	0.984	1.341
2.54	**0.815**	**1.174**	**1.569**
3.81	1.015	1.404	1.869
5.08	**1.173**	**1.562**	**2.08**
7.62	1.427	1.866	2.422
10.16	1.675	2.104	2.713
12.7	1.883	2.328	2.93

Plot of Penetration Versus Load Curve

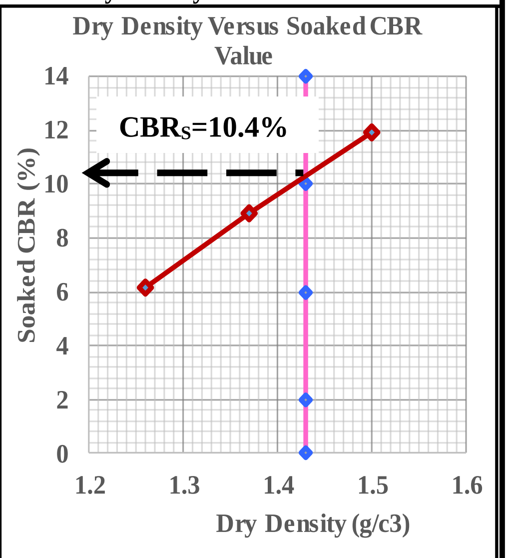


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.26	1.37	1.5
Spec. Load @ 2.54 mm	kN	0.815	1.174	1.569
Spec. Load @ 5.08 mm	kN	1.173	1.562	2.08
Stand. Load @ 2.54 mm	kN	13.2	13.2	13.2
Stand. Load @ 5.08 mm	kN	20	20	20
Soaked CBR @ 2.54	%	6.2	8.9	11.9
Soaked CBR @ 5.08	%	5.9	7.8	10.4
Soaked CBR Value	%	6.2	8.9	11.9
Data from Modified Compaction Proctor Test				
OMC	%	28.7		
MDD	g/cc	1.51		
Density required	%	95		
Target Density required	g/cc	1.43		
CBR value at Target Density	%	**10.4**		

Plot of Dry Density Versus Soaked CBR Value



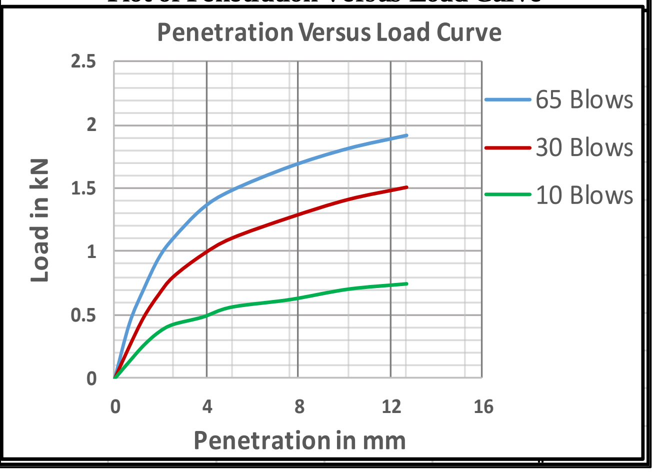
Test	California Bearing Ratio (CBR) Test, (AASHTO T193-93)											
Site	Seka Hospital								Test Pit		TP8 @ 1m	
Wet Density Determination												
	Units											
Mold Number		1			2				3			
Mass of Mold	gram	6495.9			6719.3				6551.6			
Volume of Mold	cc	2124			2124				2124			
Number of Layer		5			5				5			
Number of Blows/Layer		10			30				65			
Condition of Sample		Before Soaking		After Soaking	Before Soaking		After Soaking		Before Soaking		After Soaking	
Wt of Mold + wet soil	gram	9928.4		10290.8	10481.1		10636		10672.4		10831.1	
Weight of Wet soil	gram	3432.5		3794.9	3761.8		3916.7		4120.8		4279.5	
Wet Density	g/cc	1.62		1.79	1.77		1.84		1.94		2.01	
Moisture Content and Dry Density Determination												
Container Code		T2	P15	F	G	D	SG	O1-1	O2-1	2	O3-1	P3	O6-12
Weight of cont. + wet soil	gram	97.2	124.5	53.5	144.3	116.5	125.1	138.4	129.4	118.9	143.9	126.3	97.5
Weight of cont. + dry soil	gram	77.4	101.8	38.8	110.8	94.4	100.5	110.6	100.9	98.3	118.0	101.7	75.6
Weight of water	gram	19.9	22.7	14.8	33.5	22.1	24.6	27.8	28.5	20.6	25.9	24.6	21.9
Weight of container	gram	17.6	33.6	5.7	37.9	26.6	25.4	40.2	28.3	34.7	36.7	36.0	17.4
Weight of Dry soil	gram	59.8	68.3	33.0	72.9	67.7	75.1	70.4	72.6	63.6	81.3	65.7	58.2
Moisture content	%	33.3	33.2	44.7	45.9	32.7	32.7	39.5	39.3	32.4	31.9	37.5	37.6
Av. Moisture content	%	33.23		45.29		32.70		39.42		32.14		37.56	
Dry Density	g/cc	1.21		1.23		1.33		1.32		1.47		1.46	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.135	0.254	0.434
1.27	0.263	0.484	0.708
1.91	0.364	0.659	0.948
2.54	**0.425**	**0.798**	**1.104**
3.81	0.482	0.972	1.34
5.08	**0.561**	**1.101**	**1.482**
7.62	0.62	1.265	1.67
10.16	0.702	1.406	1.813
12.7	0.744	1.502	1.916

Plot of Penetration Versus Load Curve

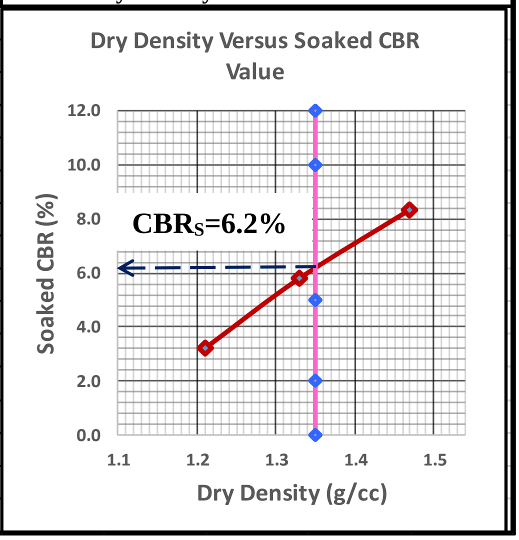


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		**10**	**30**	**65**
Dry Density	g/cc	1.21	1.33	1.47
Specimen Load @ 2.54 mm	kN	0.425	0.768	1.104
Specimen Load @ 5.08 mm	kN	0.561	1.101	1.482
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	3.2	5.8	8.4
Soaked CBR value @ 5.08	%	2.8	5.5	7.4
Larger Soaked CBR	%	3.2	5.8	8.4
Data from Modified Compaction Proctor Test				
OMC	%	34.5		
MDD	g/cc	1.42		
Density required	%	95		
Target Density required	g/cc	1.35		
CBR value at target Density	%	**6.2**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)						
Site	Seka Hospital				Test Pit		TP8 @ 2m
Wet Density Determination							
	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6675.3		6645.6		6615.5	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	10089.8	10485.3	10306.2	10564.6	10611.2	10824.7
Weight of Wet soil	gram	3414.5	3810	3660.6	3919	3995.7	4209.2
Wet Density	g/cc	1.61	1.79	1.72	1.85	1.88	1.98

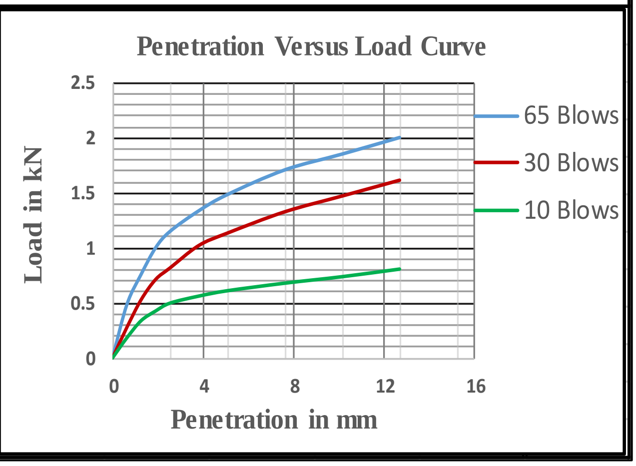
Moisture Content and Dry Density Determination													
Container Code		F	T1	T1C1	O6-11	G3T3	K-4	F	G	TC1	G19	O4-1	MK
Weight of cont. + wet soil	gram	122.1	125.7	99.6	106.4	155.0	105.1	163.6	116.3	83.2	116.3	115.1	111.8
Weight of cont. + dry soil	gram	103.2	106.3	75.2	79.8	129.0	85.4	127.9	88.9	68.9	99.0	89.7	87.1
Weight of water	gram	18.9	19.3	24.4	26.6	26.0	19.7	35.8	27.5	14.3	17.3	25.4	24.7
Weight of container	gram	36.4	37.7	17.6	17.9	37.9	17.9	36.4	17.7	17.7	37.9	17.6	17.6
Weight of Dry soil	gram	66.8	68.7	57.6	61.9	91.1	67.5	91.4	71.1	51.1	61.1	72.1	69.5
Moisture content	%	28.2	28.2	42.4	43.0	28.6	29.1	39.1	38.6	28.0	28.3	35.3	35.6
Av. Moisture content	%	28.19		42.68		28.85		38.85		28.15		35.43	
Dry Density	g/cc	1.25		1.26		1.34		1.33		1.47		1.46	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.184	0.278	0.486
1.27	0.34	0.528	0.76
1.91	0.428	0.711	1.001
2.54	**0.499**	**0.814**	**1.148**
3.81	0.563	1.017	1.335
5.08	**0.612**	**1.13**	**1.483**
7.62	0.681	1.323	1.707
10.16	0.74	1.466	1.851
12.7	0.809	1.609	2.001

Plot of Penetration Versus Load Curve

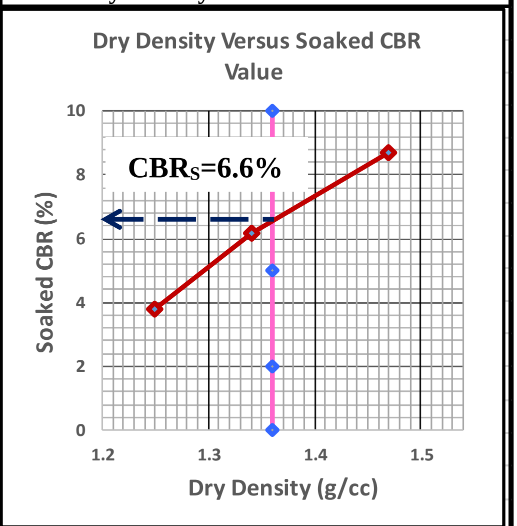


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.25	1.34	1.47
Specimen Load @ 2.54 mm	kN	0.499	0.814	1.148
Specimen Load @ 5.08 mm	kN	0.612	1.13	1.483
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	3.8	6.2	8.7
Soaked CBR value @ 5.08	%	3.1	5.7	7.4
Larger Soaked CBR Value	%	3.8	6.2	8.7
Data from Modified Compaction Proctor Test				
OMC	%	30.8		
MDD	g/cc	1.43		
Density required	%	95		
Target Density required	g/cc	1.36		
CBR value at target Density	%	**6.6**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Seka Hospital	Test Pit	TP8 @ 3m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6518.4		6547.4		6531.8	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9953.3	10447.2	10262.2	10627.6	10620.9	10864.9
Weight of Wet soil	gram	3434.9	3928.8	3714.8	4080.2	4089.1	4333.1
Wet Density	g/cc	1.62	1.85	1.75	1.92	1.93	2.04

Moisture Content and Dry Density Determination

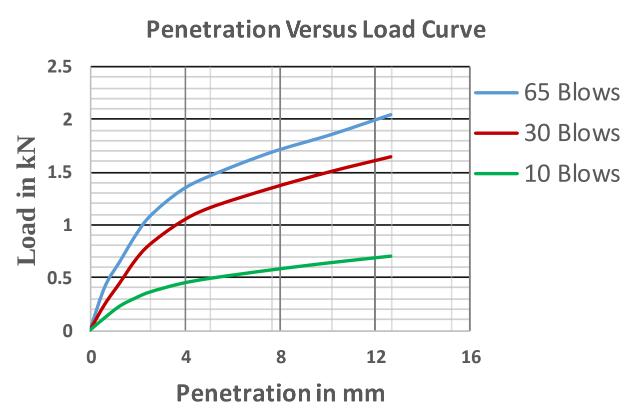
Container Code		B	DH	G3T3	K-4	G-19	P6	G19	T1C1	G	UC	A-1C	P66
Weight of cont. + wet soil	gram	95.3	94.3	166.1	109.2	86.7	89.1	166.2	101.9	62.9	74.4	174.5	166.6
Weight of cont. + dry soil	gram	78.0	76.9	123.5	78.9	71.2	72.4	126.9	76.2	52.6	61.4	139.5	131.2
Weight of water	gram	17.3	17.4	42.6	30.3	15.6	16.7	39.3	25.7	10.3	13.0	35.0	35.4
Weight of container	gram	18.2	17.0	37.9	17.9	17.8	17.1	37.9	17.7	17.9	16.7	49.7	37.5
Weight of Dry soil	gram	59.8	59.8	85.6	61.0	53.4	55.3	89.0	58.4	34.6	44.7	89.8	93.7
Moisture content	%	29.0	29.1	49.7	49.6	29.2	30.2	44.2	44.0	29.7	29.0	38.9	37.8
AvMoisture content	%	29.02		49.66		29.67		44.11		29.37		38.34	
Dry Density	g/cc	1.25		1.24		1.35		1.33		1.49		1.47	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.121	0.249	0.416
1.27	0.231	0.45	0.655
1.91	0.305	0.66	0.895
2.54	**0.364**	**0.814**	**1.085**
3.81	0.442	1.021	1.323
5.08	**0.494**	**1.161**	**1.469**
7.62	0.573	1.343	1.689
10.16	0.643	1.502	1.859
12.7	0.705	1.642	2.05

Plot of Penetration Versus Load Curve

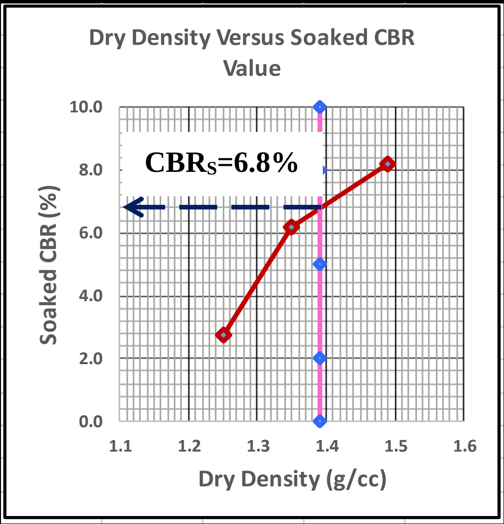


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.25	1.35	1.49
Specimen Load @ 2.54 mm	kN	0.364	0.814	1.085
Specimen Load @ 5.08 mm	kN	0.494	1.161	1.469
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.8	6.2	8.2
Soaked CBR value @ 5.08	%	2.5	5.8	7.3
Larger Soaked CBR Value	%	2.8	6.2	8.2
Data from Modified Compaction Proctor Test				
OMC	%	30.5		
MDD	g/cc	1.46		
Density required	%	95		
Target Density required	g/cc	1.39		
CBR value at target Density	%	**6.8**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Seka Preparatory School	Test Pit	TP9 @ 1m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6688		6718		6526.5	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Wt of Mold + wet soil	gram	10058.4	10328.9	10362.5	10577.8	10550.9	10701.8
Weight of Wet soil	gram	3370.4	3640.9	3644.5	3859.8	4024.4	4175.3
Wet Density	g/cc	1.59	1.71	1.72	1.82	1.89	1.97

Moisture Content and Dry Density Determination

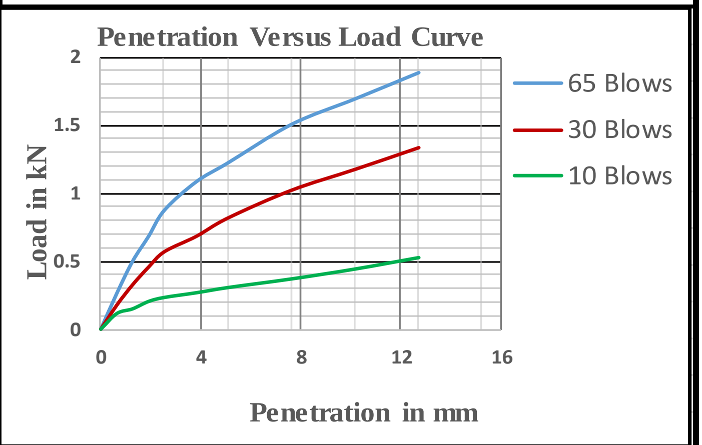
Container Code		O4-2	O4-1	10G	B3	MK	G	O1-3	G7	O6-1	P1	K-4	T1C1
Weight of cont. + wet soil	gram	87.4	84.0	90.8	82.7	72.7	88.1	113.7	99.0	56.2	46.8	115.2	103.2
Weight of cont. + dry soil	gram	70.4	67.5	69.1	63.3	59.2	70.8	87.2	76.4	46.7	39.8	89.5	81.0
Weight of water	gram	17.0	16.5	21.7	19.4	13.5	17.2	26.5	22.5	9.5	7.0	25.7	22.2
Weight of container	gram	17.7	17.6	17.7	17.4	17.6	17.7	17.5	17.4	17.5	17.9	17.9	17.7
Weight of Dry soil	gram	52.7	49.9	51.4	45.9	41.5	53.1	69.7	59.1	29.2	21.9	71.6	63.3
Moisture content	%	32.2	33.1	42.2	42.3	32.5	32.4	38.0	38.2	32.5	32.1	35.9	35.0
Av. Moisture content	%	32.65		42.23		32.45		38.10		32.30		35.45	
Dry Density	g/cc	1.20		1.21		1.30		1.32		1.43		1.45	

Summary of CBR Value from the CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.114	0.178	0.263
1.27	0.148	0.328	0.498
1.91	0.202	0.459	0.681
2.54	**0.231**	**0.572**	**0.872**
3.81	0.265	0.685	1.08
5.08	**0.303**	**0.821**	**1.219**
7.62	0.366	1.026	1.501
10.16	0.438	1.18	1.688
12.7	0.521	1.34	1.88

Plot of Penetration Versus Load Curve

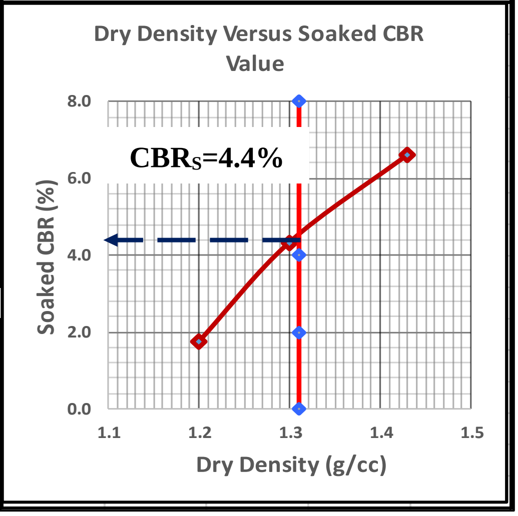


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density	g/cc	1.2	1.3	1.43
Specimen Load @ 2.54 mm	kN	0.231	0.572	0.872
Specimen Load @ 5.08 mm	kN	0.303	0.821	1.209
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	1.8	4.3	6.6
Soaked CBR value @ 5.08	%	1.5	4.1	6.0
Larger Soaked CBR Value	%	1.8	4.3	6.6
Data from Modified Compaction Proctor Test				
OMC	%	34.5		
MDD	g/cc	1.38		
Density required	%	95		
Target Density required	g/cc	1.31		
CBR Value at Target Density	%	**4.4**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)						
Site	Seka Preparatory School				Test Pit	TP9 @ 2m	
Wet Density Determination							
	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6506.4		6726		6402	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	9919.8	10161	10424.7	10642.1	10517.5	10640.3
Weight of Wet soil	gram	3413.4	3654.6	3698.7	3916.1	4115.5	4238.3
Wet Density	g/cc	1.61	1.72	1.74	1.84	1.94	2.00

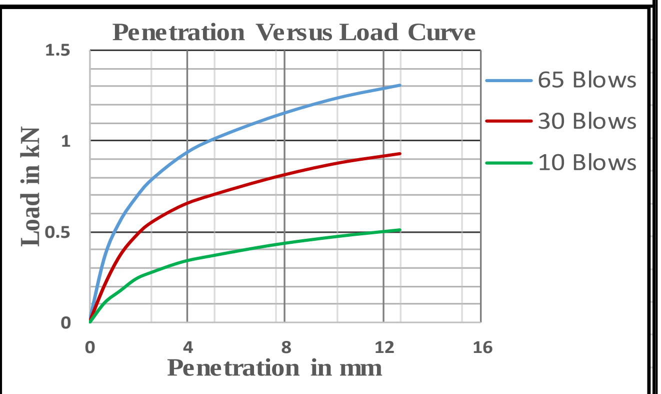
Moisture Content and Dry Density Determination													
Container Code		RG	P66	O5-2	O2-3	P3	A-13	II	G19	ZE	D	113	P66
Weight of cont. + wet soil	gram	157.5	166.3	98.3	109.6	112.2	107.8	109.1	112.7	124.4	111.5	144.0	146.9
Weight of cont. + dry soil	gram	124.5	134.3	73.7	81.4	93.3	90.1	82.6	84.5	101.7	91.1	115.3	117.2
Weight of water	gram	32.9	32.0	24.6	28.2	18.9	17.7	26.5	28.1	22.7	20.4	28.7	29.8
Weight of container	gram	25.2	37.4	17.9	17.7	36.0	36.6	18.0	17.8	33.1	29.6	37.9	37.4
Weight of Dry soil	gram	99.3	96.9	55.8	63.8	57.3	53.5	64.6	66.7	68.6	61.5	77.4	79.8
Moisture content	%	33.2	33.1	44.0	44.2	33.0	33.1	41.1	42.1	33.0	33.1	37.1	37.3
Av. Moisture content	%	33.12		44.11		33.08		41.59		33.06		37.19	
Dry Density	g/cc	1.21		1.19		1.31		1.30		1.46		1.45	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.113	0.211	0.368
1.27	0.178	0.373	0.563
1.91	0.243	0.479	0.691
2.54	**0.279**	**0.553**	**0.789**
3.81	0.337	0.647	0.924
5.08	**0.372**	**0.706**	**1.014**
7.62	0.432	0.803	1.142
10.16	0.477	0.879	1.241
12.7	0.513	0.931	1.311

Plot of Penetration Versus Load Curve

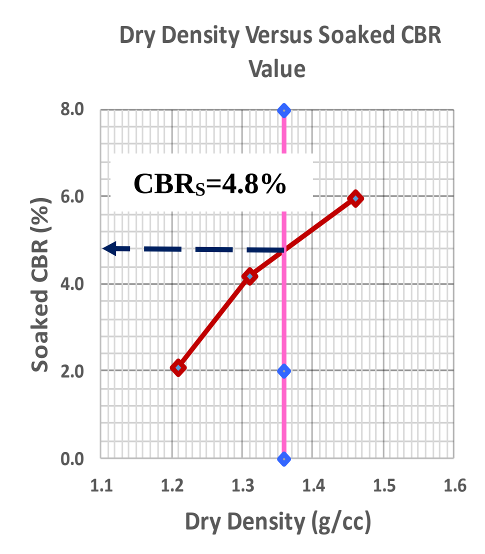


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density (Bfre Soaking)	g/cc	1.21	1.31	1.46
Specimen Load @ 2.54 mm	kN	0.279	0.553	0.789
Specimen Load @ 5.08 mm	kN	0.372	0.706	1.014
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.1	4.2	6.0
Soaked CBR value @ 5.08	%	1.9	3.5	5.1
Larger Soaked CBR Value	%	2.1	4.2	6.0
Data from Modified Compaction Proctor Test				
OMC	%	35.4		
MDD	g/cc	1.43		
Density required	%	95		
Target Density required	g/cc	1.36		
CBR Value at Target Density	%	**4.8**		

Plot of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Seka Preparatory School	Test Pit	TP9 @ 3m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6803		6795.4		6541.6	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	10203.1	10498.7	10497.2	10742.1	10579	10801.6
Weight of Wet soil	gram	3400.1	3695.7	3701.8	3946.7	4037.4	4260
Wet Density	g/cc	1.60	1.74	1.74	1.86	1.90	2.01

Moisture Content and Dry Density Determination

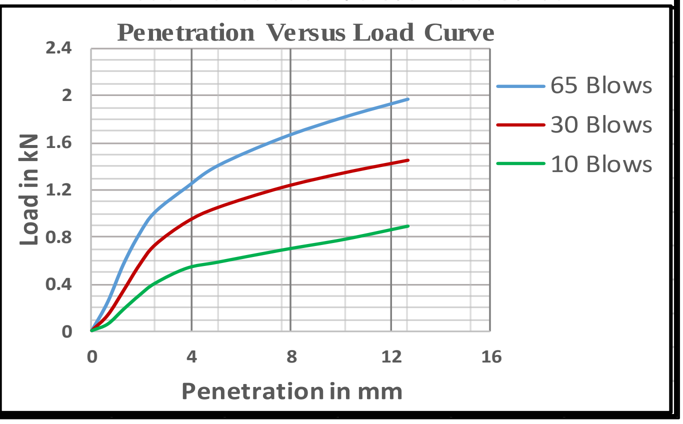
Container Code		P66	A-1C	P2	HC51	MK	P15	AT	II	DH	G	HC12	10G
Weight of cont. + wet soil	gram	119.1	130.2	122.2	123.0	85.6	118.0	116.3	117.8	81.7	95.7	112.8	113.7
Weight of cont. + dry soil	gram	100.9	112.3	90.6	90.8	70.3	99.2	88.7	90.3	67.8	78.9	88.2	88.7
Weight of water	gram	18.2	18.0	31.6	32.2	15.3	18.7	27.6	27.5	13.9	16.7	24.6	25.0
Weight of container	gram	37.5	49.7	17.5	17.7	17.6	33.5	17.6	18.0	17.0	17.9	18.1	17.7
Weight of Dry soil	gram	63.5	62.6	73.1	73.2	52.7	65.7	71.1	72.3	50.8	61.0	70.0	71.0
Moisture content	%	28.6	28.7	43.3	43.9	29.1	28.5	38.8	38.0	27.3	27.5	35.1	35.2
Av. Moisture content	%	28.64		43.59		28.80		38.40		27.40		35.14	
Dry Density	g/cc	1.24		1.21		1.35		1.34		1.49		1.48	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN)		
	10 blows	30 blows	65 blows
0	0	0	0
0.64	0.056	0.133	0.244
1.27	0.181	0.34	0.563
1.91	0.301	0.559	0.82
2.54	**0.403**	**0.73**	**1.006**
3.81	0.531	0.926	1.216
5.08	**0.583**	**1.05**	**1.401**
7.62	0.685	1.218	1.633
10.16	0.777	1.345	1.812
12.7	0.889	1.451	1.963

Plot of Penetration Versus Load Curve



Summary of CBR Value from the CBR Test Software

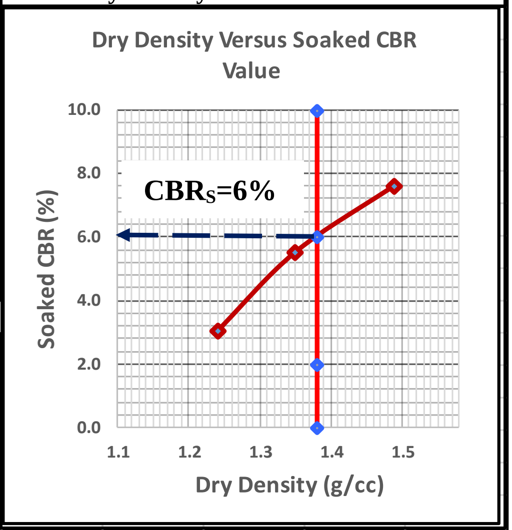
CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density (Bfre Soaking)	g/cc	1.24	1.35	1.49
Specimen Load @ 2.54 mm	kN	0.403	0.73	1.006
Specimen Load @ 5.08 mm	kN	0.583	1.05	1.401
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	3.1	5.5	7.6
Soaked CBR value @ 5.08	%	2.9	5.3	7.0
Larger Soaked CBR Value	%	3.1	5.5	7.6

Data from Modified Compaction Proctor Test

OMC	%	31.6
MDD	g/cc	1.45
Density required	%	95
Target Density required	g/cc	1.38
CBR Value at Target Density	%	**6.0**

Plot of Dry Density Versus Soaked CBR Value



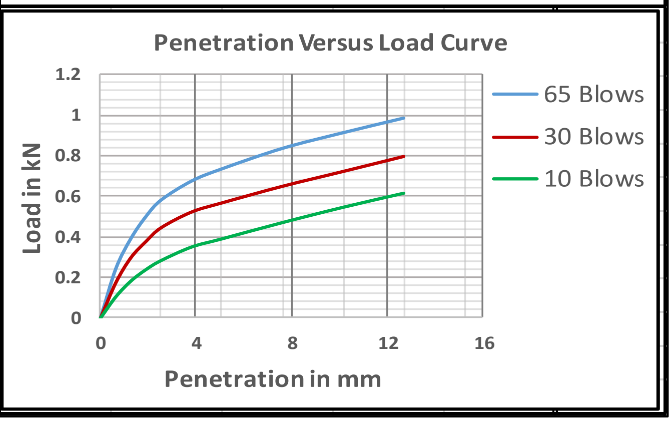
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	Lideta Orthodox Church									Test Pit		TP10 @ 1m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6525.4				6502.1				6474.2			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	9949.2		10285.4		10214.6		10438.3		10440.6		10601.4	
Weight of Wet soil	gram	3423.8		3760		3712.5		3936.2		3966.4		4127.2	
Wet Density	g/cc	1.61		1.77		1.75		1.85		1.87		1.94	
Moisture Content and Dry Density Determination													
Container Code		MK	G3T3	MK1	G10	P2	10G	K-4	T1C1	O4-2	HC12	G3T3	N
Weight of cont. + wet soil	gram	93.2	91.6	102.3	94.6	100.5	90.8	99.4	99.1	102.0	95.9	102.1	94.6
Weight of cont. + dry soil	gram	74.3	72.7	75.4	69.9	79.4	72.4	76.0	75.8	81.2	76.5	79.1	73.5
Weight of water	gram	19.0	18.9	26.9	24.7	21.2	18.3	23.4	23.3	20.9	19.5	23.0	21.0
Weight of container	gram	17.6	17.6	17.6	17.2	17.5	17.7	17.9	17.7	17.7	18.2	17.6	16.8
Weight of Dry soil	gram	56.6	55.1	57.8	52.7	61.8	54.7	58.0	58.1	63.5	58.3	61.6	56.8
Moisture content	%	33.5	34.3	46.6	46.9	34.2	33.5	40.4	40.1	32.9	33.4	37.3	37.1
Av. Moisture content	%	33.90		46.72		33.87		40.22		33.14		37.20	
Dry Density	g/cc	1.20		1.21		1.31		1.32		1.40		1.42	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	**Specimen Load (kN)**		
	10 blows	**30 blows**	**65 blows**
0	0	0	0
0.64	0.104	0.174	0.243
1.27	0.181	0.297	0.391
1.91	0.238	0.378	0.501
2.54	**0.282**	**0.445**	**0.581**
3.81	0.348	0.522	0.674
5.08	**0.388**	**0.567**	**0.734**
7.62	0.468	0.649	0.835
10.16	0.543	0.722	0.912
12.7	0.612	0.796	0.984

Plot of Penetration Versus Load Curve

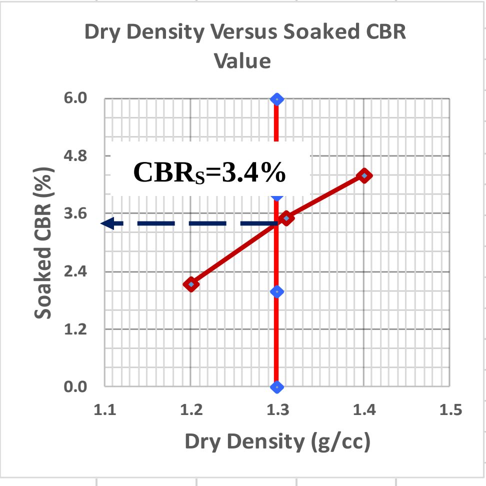


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		**10**	**30**	**65**
Dry Density (Bfre Soaking)	g/cc	1.2	1.31	1.4
Specimen Load @ 2.54 mm	kN	0.282	0.465	0.581
Specimen Load @ 5.08 mm	kN	0.388	0.567	0.734
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.1	3.5	4.4
Soaked CBR value @ 5.08	%	1.9	2.8	3.7
Reported Soaked CBR Value	%	2.1	3.5	4.4
Data from Modified Compaction Proctor Test				
OMC	%	35.8		
MDD	g/cc	1.37		
Density required	%	95		
Target Density required	g/cc	1.30		
CBR Value at Target Density	%	**3.4**		

Plots of Dry Density Versus Soaked CBR Value



Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)		
Site	Lideta Orthodox Church	Test Pit	TP10 @ 2m

Wet Density Determination

	Units						
Mold Number		1		2		3	
Mass of Mold	gram	6684.5		6850.2		6584.6	
Volume of Mold	cc	2124		2124		2124	
Number of Layer		5		5		5	
Number of Blows/Layer		10		30		65	
Condition of Sample		Before Soaking	After Soaking	Before Soaking	After Soaking	Before Soaking	After Soaking
Weight of Mold + wet soil	gram	10108.4	10453.8	10492.6	10760.1	10514.1	10675.1
Weight of Wet soil	gram	3423.9	3769.3	3642.4	3909.9	3929.5	4090.5
Wet Density	g/cc	1.61	1.77	1.71	1.84	1.85	1.93

Moisture Content and Dry Density Determination

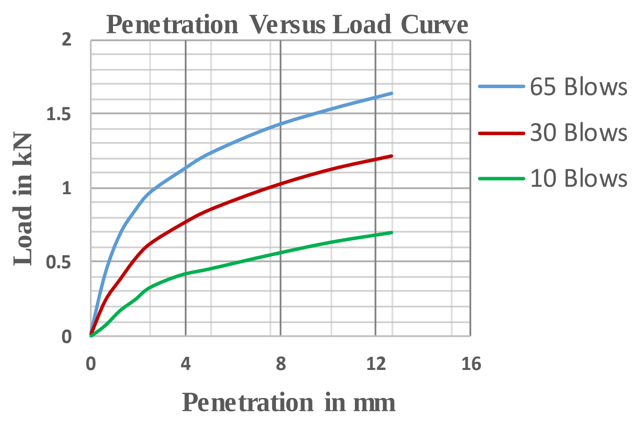
Container Code		C	P3	H	G	14	O4-3	HC12	GS=3	O6-3	O5-2	F	G
Weight of cont. + wet soil	gram	99.6	98.9	55.1	148.2	74.6	78.7	112.8	91.8	65.8	58.6	67.9	68.6
Weight of cont. + dry soil	gram	83.7	82.0	39.6	113.7	61.0	64.2	85.4	70.0	54.2	48.9	51.9	52.0
Weight of water	gram	15.8	16.9	15.5	34.5	13.6	14.4	27.5	21.9	11.5	9.7	16.0	16.7
Weight of container	gram	32.8	25.8	5.7	37.9	17.4	17.6	18.1	18.4	17.1	17.8	6.3	5.6
Weight of Dry soil	gram	50.9	56.2	33.9	75.8	43.6	46.6	67.2	51.6	37.1	31.1	45.6	46.4
Moisture content	%	31.1	30.1	45.8	45.6	31.2	30.9	40.9	42.4	31.0	31.0	35.0	35.9
Av. Moisture content	%	30.60		45.66		31.06		41.62		31.02		35.46	
Dry Density	g/cc	1.23		1.22		1.31		1.30		1.41		1.42	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.077	0.242	0.424
1.27	0.178	0.386	0.691
1.91	0.253	0.525	0.851
2.54	**0.335**	**0.626**	**0.971**
3.81	0.417	0.751	1.111
5.08	**0.461**	**0.855**	**1.234**
7.62	0.555	1.005	1.406
10.16	0.64	1.124	1.529
12.7	0.705	1.213	1.634

Plot of Penetration Versus Load Curve

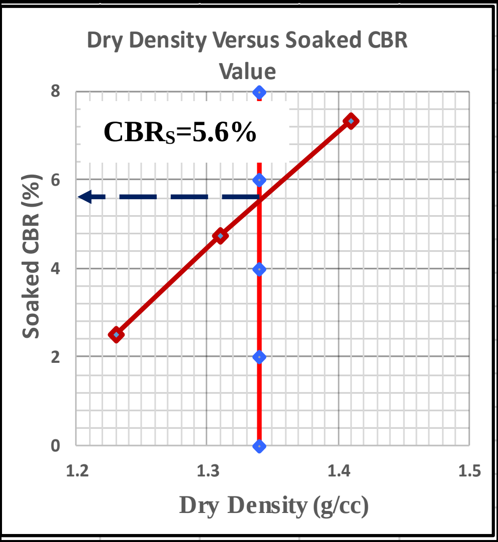


Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density (Bfre Soaking)	g/cc	1.23	1.31	1.41
Specimen Load @ 2.54 mm	kN	0.335	0.626	0.971
Specimen Load @ 5.08 mm	kN	0.461	0.855	1.234
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	2.5	4.7	7.4
Soaked CBR value @ 5.08	%	2.3	4.3	6.2
Larger Soaked CBR value	%	2.5	4.7	7.4
Data from Modified Compaction Proctor Test				
OMC	%	33.6		
MDD	g/cc	1.41		
Density required	%	95		
Target Density required	g/cc	1.34		
CBR value at Target Density	%	**5.6**		

Plot of Dry Density Versus Soaked CBR Value



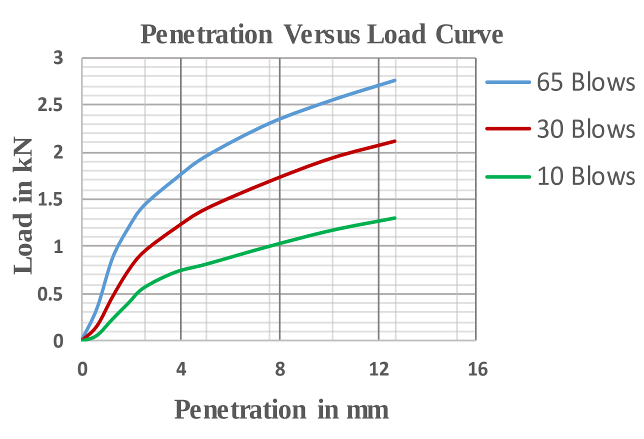
Test	California Bearing Ratio (CBR) Test, (AASHTO T 193-93)												
Site	Lideta Orthodox Church									Test Pit		TP10 @ 3m	
Wet Density Determination													
	Units												
Mold Number		1				2				3			
Mass of Mold	gram	6528.9				6511.7				6501.6			
Volume of Mold	cc	2124				2124				2124			
Number of Layer		5				5				5			
Number of Blows/Layer		10				30				65			
Condition of Sample		Before Soaking		After Soaking		Before Soaking		After Soaking		Before Soaking		After Soaking	
Weight of Mold + wet soil	gram	9994.1		10371.4		10461.8		10727.9		10670.5		10833.7	
Weight of Wet soil	gram	3465.2		3842.5		3950.1		4216.2		4168.9		4332.1	
Wet Density	g/cc	1.63		1.81		1.86		1.99		1.96		2.04	
Moisture Content and Dry Density Determination													
Container Code		C3	MK	T1	F	D	P15	G	DH	GS-6	SR	P15	MK
Weight of cont. + wet soil	gram	152.2	117.3	133.6	144.6	127.7	156.8	120.2	111.9	64.6	64.5	150.7	97.6
Weight of cont. + dry soil	gram	123.7	94.8	103.5	111.0	105.1	128.6	90.5	84.7	55.6	55.6	119.3	76.4
Weight of water	gram	28.5	22.5	30.1	33.6	22.6	28.2	29.7	27.2	9.0	8.9	31.4	21.2
Weight of container	gram	26.7	17.6	37.7	36.4	29.6	33.5	17.9	17.0	25.2	25.3	33.5	17.6
Weight of Dry soil	gram	97.0	77.1	65.8	74.6	75.5	95.1	72.6	67.7	30.4	30.3	85.8	58.8
Moisture content	%	29.4	29.2	45.8	45.0	30.0	29.7	40.9	40.1	29.5	29.5	36.6	36.1
Av. Moisture content	%	29.28		45.40		29.81		40.51		29.46		36.33	
Dry Density	g/cc	1.26		1.24		1.43		1.41		1.52		1.50	

Summary of CBR Data from CBR Test Software

Penetration vs Load data

Penetration (mm)	Specimen Load (kN) 10 blows	30 blows	65 blows
0	0	0	0
0.64	0.063	0.163	0.348
1.27	0.236	0.472	0.881
1.91	0.405	0.75	1.201
2.54	**0.569**	**0.951**	**1.439**
3.81	0.734	1.201	1.722
5.08	**0.821**	**1.411**	**1.967**
7.62	1.01	1.699	2.311
10.16	1.18	1.947	2.558
12.7	1.31	2.126	2.767

Plot of Penetration Versus Load Curve



Summary of CBR Value from the CBR Test Software

CBR Test Summary Value

	Units			
Number of blows		10	30	65
Dry Density (Bfre Soaking)	g/cc	1.26	1.43	1.52
Specimen Load @ 2.54 mm	kN	0.569	0.951	1.439
Specimen Load @ 5.08 mm	kN	0.821	1.411	1.967
Standard Load @ 2.54 mm	kN	13.2	13.2	13.2
Standard Load @ 5.08 mm	kN	20	20	20
Soaked CBR value @ 2.54	%	4.3	7.2	10.9
Soaked CBR value @ 5.08	%	4.1	7.1	9.8
Reported Soaked CBR Value	%	4.3	7.2	10.9
Data from Modified Compaction Proctor Test				
OMC	%	31.5		
MDD	g/cc	1.47		
Density required	%	95		
Target Density required	g/cc	1.40		
CBR Value at target Density	%	**6.8**		

Plot of Dry Density Versus Soaked CBR Value